Instructions

For

Installing and Operating

Bipolar Generators

For

Incandescent Lighting

General Electric Company

Schenectady, N. Y.

No. 8007.

Nov. 1, 1894.

INSTRUCTIONS

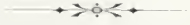
FOR

INSTALLING AND OPERATING

BIPOLAR GENERATORS

FOR

INCANDESCENT LIGHTING



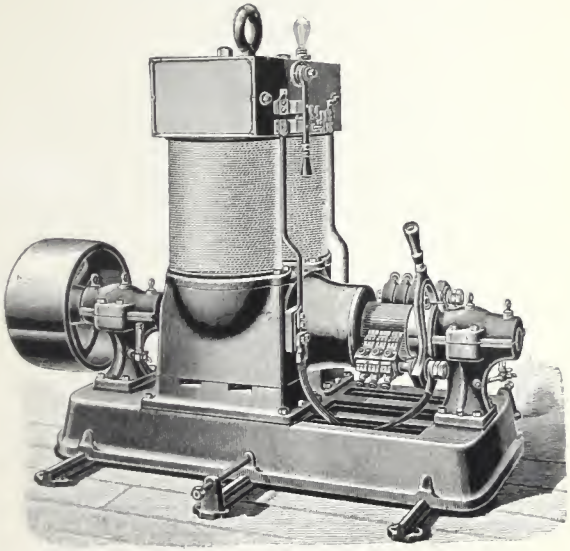
GENERAL ELECTRIC CO.

SALES OFFICES.

MAIN OFFICES, SCHENECTADY, N. Y.

SALES OFFICES:

BOSTON, MASS., 180 SUMMER STREET.
NEW YORK, N. Y., 44 BROAD STREET.
Syracuse, N. Y., 244 West Fayette Street.
Buffalo, N. Y., Erie County Savings Bank Building.
PHILADELPHIA, PA., 509 ARCH STREET.
Pittsburgh, Pa., 425 Wood Street.
BALTIMORE, MD., 227 EAST GERMAN STREET
ATLANTA, GA., EQUITABLE BUILDING.
CINCINNATI, OHIO, 264 WEST FOURTH STREET.
Cleveland, Ohio, 510 Cuyahoga Building.
CHICAGO, ILL., MONADNOCK BUILDING.
Kansas City, Mo., New York Life Building.
St. Louis, Mo., Wainwright Building.
Dallas, Texas, Corner Field and Main Streets.
DENVER, COLO., 505 16th STREET, KITTREDGE B'D'G.
SAN FRANCISCO, CAL., 15 FIRST STREET.
Helena, Mont., Electric Building.
PORTLAND, ORE., FRONT AND ANKENY STREETS.
Seattle, Washington, Bailey Building.
CANADA, CANADIAN GENERAL ELECTRIC COMPANY, LTD.
TORONTO, ONT.
FOREIGN DEPT. { SCHENECTADY, N. Y.
{ NEW YORK OFFICE, 44 BROAD STREET.



INSTRUCTIONS FOR INSTALLING AND OPERATING EDISON BIPOLAR GENERATORS.

LOCATING AND SETTING OF GENERATORS.

The only proper location for an electric generator is a cool, dry, well ventilated room, free from dust or flying particles of any kind. Basements, unless well drained and well ventilated, should be avoided.

Provide a substantial foundation of timber or mason work and see that it has a suitable footing and is sufficiently heavy and well bonded to check all vibration of the machine.

Take care to guard against irregular settling or distortion of foundation which will throw the armature out of line with the driving shaft. In locating the foundation provide for an easy access to all parts of the generator, and allow for sufficient distance between pulley centers. (See table opposite page 8.)

In constructing the foundation, provision is to be made for the anchor bolts fastening the wooden *base frame*.

The base frame is made of well seasoned timber and should receive several coats of hot asphalt varnish before setting. On this frame the *sliding rails* are placed to allow for moving the generator and adjusting the belt tension. The frontispiece shows the rails and the shifting screw.

The wooden frame serves the very important purpose of insulating the machine from the ground.

Set the generator, if possible, so that the belt pull will come on the under side of the pulley.

Do not bolt the rails to the base timbers until the armature shaft has been lined up with the driving shaft, the belt put on and the generator run for a time, to insure that the alignment is correct.

When the generators are located on a floor above the driving shaft, a lifting device is used instead of the rails for regulating the belt tension.

ASSEMBLY OF THE GENERATOR.

Parts of generators, when marked, should be assembled strictly according to the marking.

Keep all parts of the apparatus clean. The surfaces of yoke and field blocks must be carefully wiped and cleaned before bolting on the magnet cores; oil or dirt in the joints will reduce the strength of the magnets.

The armature and field coils must be handled carefully, as any breaking of the insulation is likely to cause serious trouble when current is put on.

In handling the armature, use the methods shown on pages 9 and 10, and do not allow any weight to come on the commutator, even for an instant.

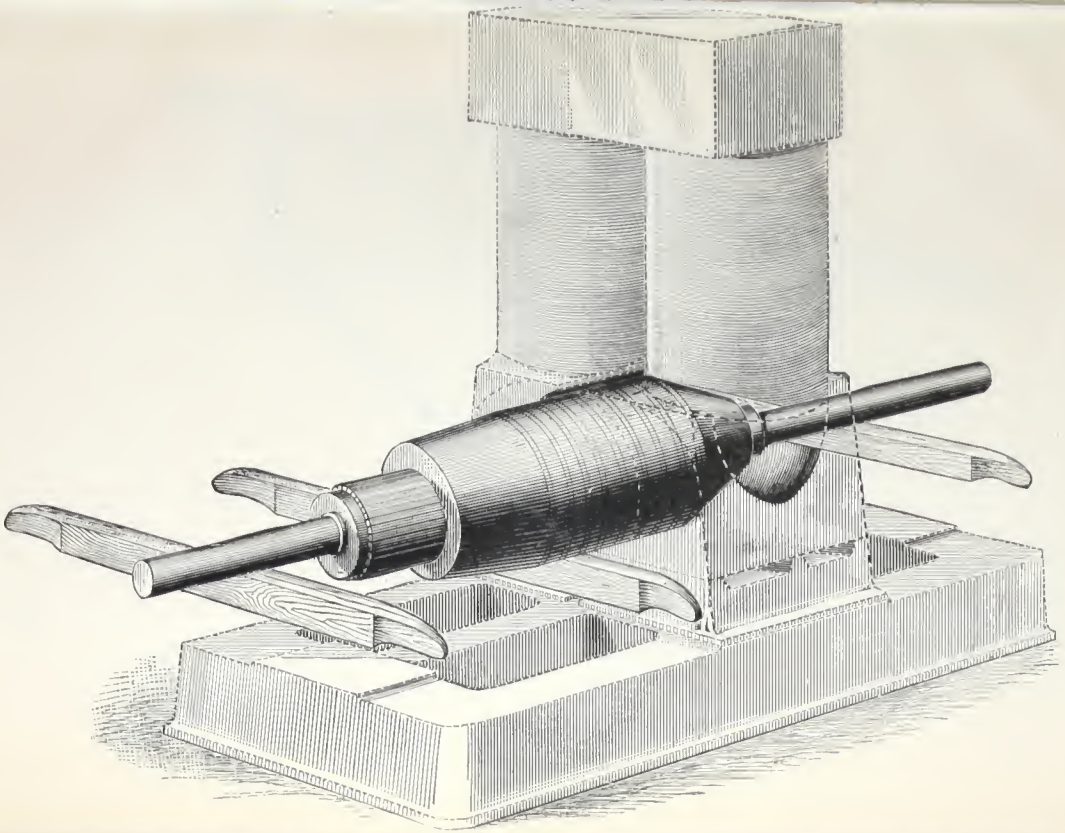
If the armature is to be laid on the floor, put a thick pad of sacking or a bag of shavings under it.

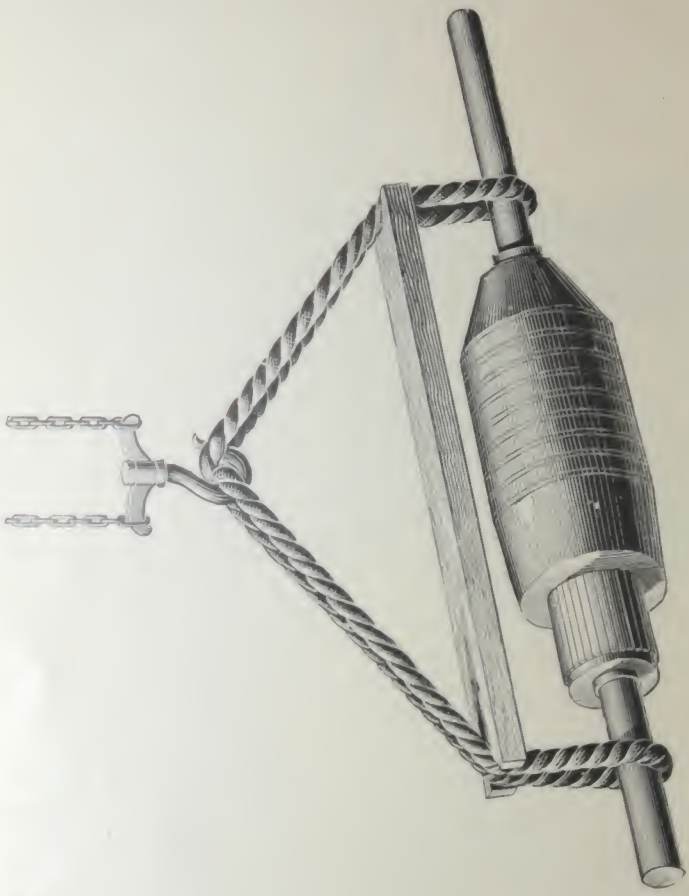
Diagram No. 13038 gives the weight, and other data, on armatures.

DIMENSIONS
A.C. GENERATORS

ON LIFTING DEVICE.

U	K	L	M	N	P	Q	R	S	T	U	V





Special care must be observed to have the pillow blocks carefully adjusted, the surfaces clean and well oiled, both on shaft and bearing, before fitting together.

It is quite important that before a new generator is put at steady work it should be first run a few hours at slow speed, which may gradually be increased to the maximum. During this trial run without current, carefully attend to the bearings, correct any tendency to heating by a liberal supply of oil and scrape the shell if absolutely necessary, but the greatest care must be exercised in doing so.* Make sure that all these things are in perfect condition previous to putting the generator at work on the circuit.

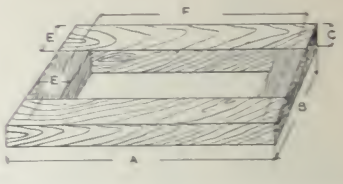
After getting a new generator ready to run, having made all the electrical connections (except between it and the bus line), start it up, charge the field, and make it generate sufficient current to light its pilot lamp. This will assure you that you actually have it in proper condition for producing a current. Having satisfied yourself on this point the connection can be made to the bus line.

---

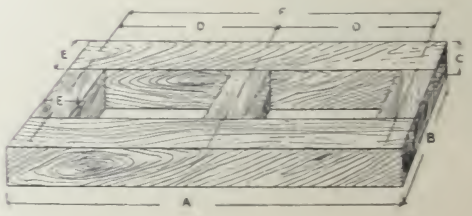
* See special instructions on starting new self-oiling bearings, page 21.

TABLE

Showing Dimensions of Dynamo Base Frames.



	TYPE OF DYNAMO.	A.	B.	C.	D.	E.	F.
Without Center Pieces	3 Kw.	26	25	3½		6	19
	6 "	30	29	3½		6	22½
	8½ "	34½	30½	3½		6	25
	12 "	32¼	31½	3¼		6	24½
	15 "	49½	37½	6		8	30
	20 "	47	40	6		8	38
	25 "	46	42	6		8	35
	30 "	50½	48½	6		8	38
With Center Pieces.	45 "	62	50	6	26	8	52
	60 "	72	54	8	29½	12	59½
	100 "	82	64	8	34½	12	69
	150 "	91½	78½	8	38½	12	77



CLEANLINESS ABOUT THE GENERATOR IS ESSENTIAL.

All parts of the generator should be kept neat and clean. Dirt, copper dust and oil should not, under any circumstances, be allowed to gather on any part, especially in crevices near those parts which are carrying current.

Copper dust in even small particles may be a source of much annoyance. It is very detrimental to the generator, and will seriously endanger the durability of the insulation on magnets and armature.

Oil cans, tools, bolts and pieces of iron should be kept away from the generator, as they are liable to be drawn into the field and injure the armature.

A good rule is: *Never allow a loose article of any kind to be placed upon any portion of a generator.*

They are not only liable to be drawn in, but to fall upon the armature or commutator.

Brass or copper oil cans are best to use, as they are non-magnetic.

SWITCHES, CONNECTIONS AND CONTACTS.

A large, clean surface contact is necessary.

The contact surfaces of switches and all connections should be sufficiently firm to secure good conductivity, and be kept clean and bright. All connecting screws should be set firmly and securely down.

When the generator is not in operation leave the switch open. All contacts and connections should be frequently inspected, while the generator is in operation, to see that there is no undue heating, and should be gone over thoroughly at intervals to detect any loose or insecure connections.

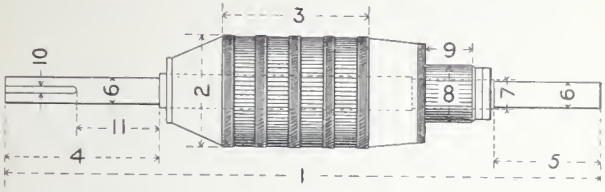
TABLE

Showing Diameter and Face of Pulleys, Belt Widths, and Minimum Distance between Center of Engine and Generator Pulleys for Edison Standard Generators.

RATING OF GENERATOR IN KILOWATTS.	DIAMETER OF PULLEY IN INCHES.	FACE OF PULLEY IN INCHES.	WIDTH OF BELT IN INCHES.	MIN. DISTANCE BETWEEN CENTER OF PULLEYS IN FEET.
.5	3½	2	1½	6
.75	3½	2½	2	6
1.5	4	3	2	8
3	7½	3	2	10
6	8	4	3	10
8.5	8½	5	4	12
12	9	6	5	12
15	11¼	8	7	12½
20	12	9	8	13
25	13	10	9	14
30	14	11	10	14
45	17	12	11	15
60	24	13	12	15
100	26	16	15	16
150	44	21	20	16

NOTE. — The above data is based on the assumption that the arc of contact will be fully 180° on each pulley.

GENERAL DIMENSIONS OF ARMATURES FOR EDISON BI-POLAR DYNAMOS.



CLASS KW.	NET WEIGHT 125 V.	NET WEIGHT 500 V.	RESIST. 125 V.	RESIST 500 V.	1	2	3	4	5	6	7	8 125 V.	8 500 V.	9 125 V.	9 500 V.	10	11
·5	9	9	3·32		16 3/8	2 5/16	4	4 1/2	2 5/16	1/2	9/16	2		2 9/32	—	—	—
·75	14 1/2	15	1·66	4·0	20 1/4	3 1/4	5	5 1/4	2 1/16	5/8	3/4	2 1/4	2 9/16	1 13/16	1 1/16	—	—
1·5	27	27	·815	17	23 7/8	4 5/16	6 1/2	6 1/16	2 7/8	5/8	3/4	2 1/2	2 1/2	2 1/4	2 1/4	—	—
3	60	60	·331	5·8	32 5/16	5 5/16	8	8 11/16	5	7/8	1 1/8	3 3/8	3 3/8	2 1/4	2 1/4	5/16	5 3/8
6	100	100	·116	2·29	37 3/8	6 5/8	9 1/4	10	5 1/2	1 1/8	1 3/8	3 1/2	3 1/2	2 7/8	2 7/8	3/8	5 7/8
8·5	125	125	·068	1·16	42 5/8	6 7/8	10	11 1/4	6 1/4	1 1/4	1 1/2	3 7/8	3 7/8	2 7/8	2 7/8	3/8	6 3/4
12	160	160	·0425	·726	46 7/8	7 1/8	12	13	7 3/4	1 1/2	1 3/4	4 1/2	4 1/2	3	2 13/16	7/16	8
15	220	220	·032	·6	55 1/16	7 3/4	13 1/2	16	9 5/8	1 7/8	2 1/8	4 13/16	4 13/16	4 3/4	4 3/16	1/2	10
20	320	325	·02	·325	63 13/16	8 7/8	15	18	10 3/4	2 1/8	2 3/8	5 1/4	5 3/16	5 1/4	5 1/16	1/2	11 1/2
25	410	410	·0167	·292	66 3/16	9 3/4	16 1/2	19 3/4	11 3/16	2 3/8	2 5/8	5 13/16	6 1/4	5 3/16	5 1/16	5/8	12 1/4
30	530	520	·0108	·179	71 13/16	10 5/16	18	22	13	2 3/4	2 15/16	6 5/16	6 3/4	5 3/16	5 1/16	5/8	13 3/4
45	805	800	·009	·162	81 3/4	12 1/4	20 1/2	24	13 5/8	3	3 1/2	6 13/16	8 3/16	5 9/32	5 3/8	3/4	14 1/2
60	1170	1180	·009	·085	90 1/16	13 7/8	24 1/2	27 1/4	14 7/8	3 1/4	3 3/4	6 7/8	7 1/8	5 13/16	5 5/16	3/4	16
100	2155	2105	·00515	·055	102 3/8	17 5/8	25	29 1/2	16 1/8	3 3/4	4 1/2	9 5/16	9 1/4	8 1/8	8 1/2	7/8	19
150 400 V.	4880	—	·00252	—	117 5/8	25 1/4	26 1/2	35 1/2	15 5/8	5 1/2	6	12 1/2	—	15 3/8	—	1	21 3/4
150 500 V.	—	3700	—	·03	117 3/8	21 1/16	32	35 1/2	15 5/8	5 1/2	6	—	11 7/8	—	9 5/8	1	21 3/4
200 500 V.	—	6600	—	·0255	132 1/2	25 1/4	34 1/4	37	21	5 1/2	6 3/8	—	15	—	15	1	22

No. 13038. GENERAL ELECTRIC CO. MAR. 10, '93.

SPEEDS OF EDISON BIPOLAR GENERATORS.

VOLTS	KILOWATTS.															
	.5	.75	1.5	3	6	8.5	12	15	20	25	30	45	60	100	150	200
100	1920	1920	1680	1530	1440	1360	1290	1200	1120	1040	960	800	720			
105	2020	2020	1760	1600	1510	1430	1345	1260	1180	1090	1010	840	750			
110	2115	2115	1850	1675	1585	1500	1410	1320	1235	1145	1060	880	675			
115	2210	2210	1930	1750	1660	1565	1470	1380	1290	1200	1100	920	645	515	350	
120	2305	2305	2020	1825	1730	1630	1535	1440	1345	1250	1150	960	670	540	385	
125	2400	2400	2100	1900	1800	1700	1600	1500	1400	1300	1200	1000	700	570	400	
130												1040	730	595	420	
135												1080	755	625	435	
140												1120	785	650	450	
300	1920	1920	1680	1530	1440	1360	1280	1200	1120	1040	960	800	560	515		
310	2020	2020	1760	1600	1510	1430	1345	1260	1180	1090	1010	840	590	540		
320	2115	2115	1850	1675	1585	1500	1410	1320	1235	1145	1060	880	615	570		
330	2210	2210	1930	1750	1660	1565	1470	1380	1290	1200	1100	920	645	595		
340	2305	2305	2020	1825	1730	1630	1535	1440	1345	1250	1150	960	670	625		
350	2400	2400	2100	1900	1800	1700	1600	1500	1400	1300	1200	1000	700	650		
360												1040	730	675		
370												1080	755	700		
380												1120	785	730		
400		1920	1680	1530	1440	1360	1280	1200	1120	1040	960	800	640			
420		2020	1760	1600	1510	1430	1345	1260	1180	1090	1010	840	670			
440		2115	1850	1675	1585	1500	1410	1320	1235	1145	1060	880	700			
460		2210	1930	1750	1660	1565	1470	1380	1290	1200	1100	920	735	595	485	415
480		2305	2020	1825	1730	1630	1535	1440	1345	1250	1150	960	770	625	505	430
500		2400	2100	1900	1800	1700	1600	1500	1400	1300	1200	1000	800	650	525	450
520												1040	830	675	545	470
540												1080	865	700	565	485
560												1120	895	730	585	505

SPEED.

In order to produce the most satisfactory results the generator must be run at its normal speed.

The highest efficiency of the generator is obtained only when running at its proper speed. If the speed falls off, the magnetic field must be made stronger in order to keep the pressure up, and a largely increased amount of current is required to secure a small increase of strength in the magnetic field. The result is that the efficiency diminishes. (See list of speeds, page 16.)

OIL.

The high speed at which the machine runs requires a lubricant especially adapted for such speeds. Uniformity of rotation and absolute reliability are of first importance.

The value of an oil depends more upon its power to reduce friction and prevent the excessive development of heat, than upon its market price. Cheapness can never compensate for inferior quality.

The characteristics which should be possessed by the oil in order to be most efficient as a lubricant for generators are:

1. Sufficient density or body to keep the surfaces, between which it is interposed, from coming in contact under greatest pressure.

2. The greatest adhesion to metallic surfaces, and the least cohesion in its own particles, are qualities of the best oils, and in this respect fine mineral oils stand first.

3. The fluidity of the oil should be as much as is consistent with the above conditions.

Keep the oil free from gritty matter. All foreign matter injures the quality of the oil, and tends to increase the heat of bearings.

New oil should always be filtered.

Economy in the use of oil depends largely upon the method of applying it. By the use of oil cups with adjustable feed a perfectly uniform supply of the minimum safe quantity can be applied to the journal.

Careful experiment will show how many drops of oil per minute are required for proper lubrication.

Oil, after passing through the journal, is drawn off from the interior of the pillow block. If of good quality, it has not deteriorated, and may be filtered and used over again.

CARE OF OIL CUP BEARINGS.

Attention must be given to the oil cups and bearings of the generator while running. The supply of oil should be constant and of the minimum amount required for perfect lubrication.

Watch the bearings on a new generator very closely for a few days and use oil liberally.

After a machine has been in operation a few days, all bearings should be made to work at a normally low temperature.

Under proper conditions no reasonable excuse can be offered or accepted for abnormal heating. If it exists, it needs immediate investigation and remedy.

After being in operation a short time, a certain amount of heat is imparted to the bearings by the armature—any undue heating aside from this requires an immediate remedy by the attendant.

The temperature may reach blood heat when running with full load. The commutator bearing may be expected to become slightly warmer than the pulley bearing.

Undue heating may result from a variety of causes. Among these may be mentioned insufficient quantity or poor quality of oil, dirt or gritty matter in oil, a badly scraped bearing, rough journal, boxes too tight, belt too tight, an armature shaft slightly bent, bearings out of line, or generator overloaded.

If from any cause a bearing becomes unduly warm, a liberal supply of oil may be sufficient to check the heat. If it gets very hot the cap screws should be slightly loosened, the oil cup removed, and oil, cooled in water, plentifully applied. It is not advisable, however, to use water on the interior of the bearing unless sure that it is free from dirt or gritty particles.

The cause of the heating should always be ascertained and remedied, and the boxes removed, cleaned, scraped, and accurately refitted before starting up again.

After removing a pillow block be scrupulously careful in replacing to see that the contact surfaces and steady pins are free from grit, fibres of waste, or any kind of dirt.

If the bearings should become considerably worn, there is danger that the armature may rub on the bottom or side of the field blocks, and loosen the binding wires, which is sure to ruin the armature. By observing the position of the armature in the field, it may readily be seen whether the bearings are worn down to any considerable extent.

A small amount of wear downwards may be remedied by raising the pillow blocks with a piece of cardboard or sheet iron. If they are badly worn, or worn sideways, the bearings should be rebabbitted.

BEARINGS OUT OF LINE MAY BE DUE TO:

1. An uneven foundation causing a distortion of generator base:
2. Improper setting and bolting of the pillow blocks:
3. Improper fitting in place of the babbitt shell.

BOXES TOO TIGHT.

This can be remedied by loosening up the nuts holding cap of pillow block; a layer of cardboard of proper thickness may be inserted on the joint under cap and the nuts screwed down.

BELTS TOO TIGHT.

CAUSES.

1. Abnormally short belt.
2. Belt of insufficient width.
3. Belt of poor quality or lacking in thickness.

The pulleys on all generators have been carefully proportioned so that when belts are applied according to specifications, the full load can be pulled without trouble.

BENT ARMATURE SHAFT.

This is a rare occurrence, and can be remedied only by a competent machinist.

A sprung shaft should be straightened very carefully in a lathe. In springing it true, a pad of cloth or waste and a block rounded to fit armature body should be used between the end of pry and the armature. This is an operation requiring care, as the insulation is liable to be jammed.

OVERLOADED GENERATOR.

This would cause excessive strain on belt and a necessary tightening thereof; also an abnormal heating of armature, and the increased internal heat conducted to bearings.

SELF-OILING BEARINGS.

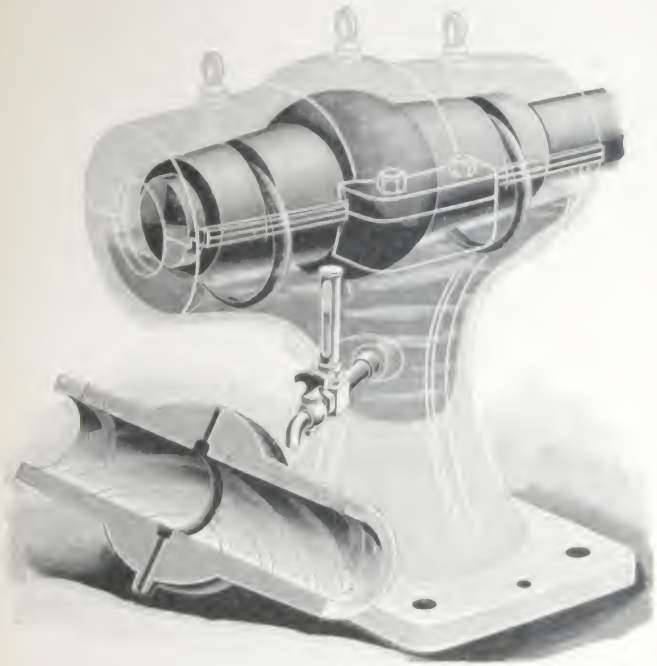


Fig. 3.

A new self-oiling bearing for generators has been devised which aims to secure absolute reliability against heating, as well as perfect and economical lubrication.

Little attention is required, and there is much less danger of undue heating than with the ordinary bearing.

They can be fitted to existing generators in place of the old bearings, and are great savers of oil.

With the construction shown in cut, the revolving rings carry from the reservoir to both ends of the sleeve a continual supply of oil which is swept, by the action of the revolving shaft, on the spirals

towards the center of the bearing, where it is collected by the central groove and returned by the hole to the reservoir, where it has time to settle and cool. By these means a continual circulation of oil through the bearing is automatically started, kept up and stopped by the motion of the shaft, the bearings requiring no attention beyond a periodical examination and, when necessary, renewal of the oil, which may be drawn off from the reservoir by a pet cock.

This bearing will only act for running in one direction. To run the shaft the other way the sleeve would have to be turned end for end. It is, therefore, **imperative** that the bearings be correctly put together. For this purpose an arrow is stamped on the upper surface of the ball bearing of the sleeve, and the latter must be set so that looking down on the bearing the upper surface of the shaft runs in the direction that the arrow points.

The bearings should be examined once a week, although the oil does not require renewal as often as that.

NOTE.

Extra care and attention must be given to starting a new generator with self oiling bearing, or in first use of these new bearings on an old generator. Watch them carefully and give frequent attention until you are sure that no undue heating will be developed.

CHARGING FIELD MAGNETS.

At the factory the Edison bipolar generators are wound and charged in such a manner that the positive (+) current will always be derived from the under brush, if the inside end of the R.H. magnet is connected to that brush.

Any change in the direction of rotation of the armature is compensated for by alteration of the magnet connections on the head board. A generator having been once magnetized should always thereafter retain sufficient residual magnetism to charge itself. If

through accident or otherwise it should become demagnetized, it may be again charged by current from another generator or a gravity or bi-chromate battery may be used.

In charging field magnets with a battery the copper or carbon plate is to be applied to the terminal connected to the under brush. One cell of storage battery, two of bi-chromate or Bunsen, or six of gravity or Le Clanche should be used. The generator current is more satisfactory. To determine the + pole in the case of the generator current, use the ordinary test paper, or put both ends of the wire into a glass of water. Both wires will give off bubbles of gas, but the + much **less** than the —. In testing the generator current a lamp should always be placed in circuit with the testing wires to prevent a short circuit.

In charging the magnets the positive pole of the battery is connected to the terminal of the inside wire of the right-hand coil, facing the head-board, and the negative pole to the left-hand coil. This will make the right-hand pole a south pole, and the left-hand pole a north pole.

In the Central Station generator there are four binding posts for the field lines, two at each end of the switchboard. (See diagram No. 13006.)

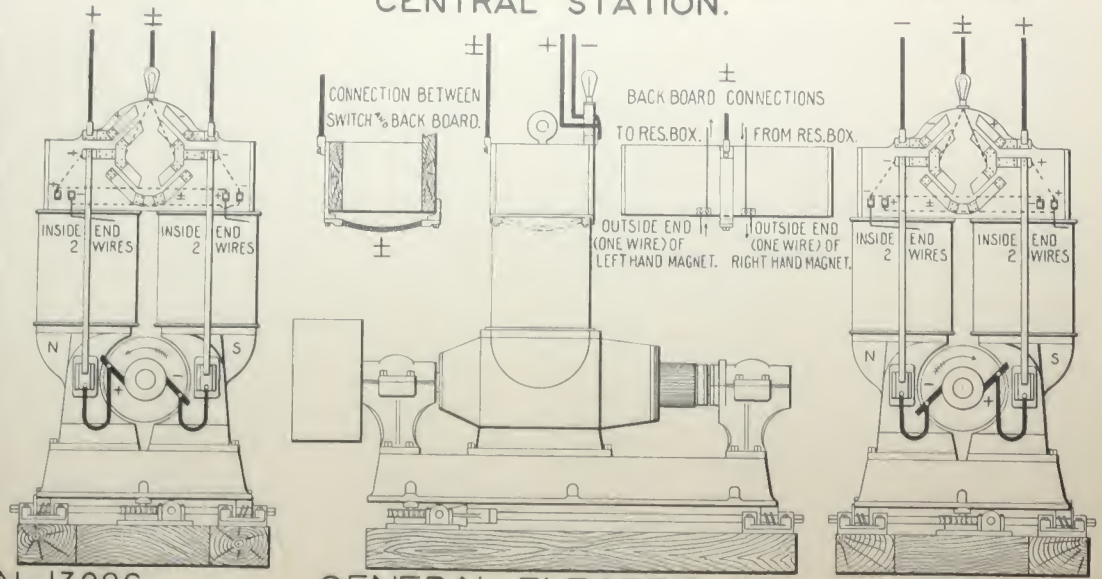
The inside terminal of each coil is brought to one or another of these posts according to the direction of rotation.

If the armature revolves from right to left, the terminals of the field magnets must be connected to the inside posts. The left or under brush will then be positive, and the right or upper negative.

If the armature revolves from left to right, the magnet terminals must be connected to the outside posts. The right or under brush will then be positive, and the left or upper brush negative.

The two outside wires of the field magnets should be brought to connecting plates on back board of generator, to which the wires from the regulator are attached.

CONNECTIONS FOR
EDISON BI-POLAR GENERATORS.
CENTRAL STATION.



No. 13006. GENERAL ELECTRIC CO. DEC. 17, '92.

W.B.C.

In both cases, when the magnets are charged, so that the right-hand pole is the south pole, and the left-hand the north pole, the under brush is positive.

The polarity of the coils should never be reversed.

If by any chance the polarity of the field magnets becomes reversed, the field connections remaining as above, the conditions described will be reversed.

The polarity of the wires is reversed either by reversing the polarity of the field magnets or the direction of rotation of the armature.

Reversing the polarity of a generator does not impair its efficiency

TESTING FIELD AND ARMATURE.

The generator must at intervals be disconnected from the circuit and throughly tested to make sure that the armature and field wires are free from leakage between the windings and the base. This test should be made at regular intervals with a Galvanometer and Rheostat, and a record kept of the readings.

If a galvanometer is not to be had, use a magneto bell.

The insulation between the body of the generator and all parts of the circuit must be perfectly maintained. Avoid loose coils or loops in the field connections. If the insulation on the flexible cables leading from brushes becomes worn after long use have it renewed.

A standard insulation of one megohm should be maintained from armature and fields to base and from base to earth.

The faults which are liable to occur in both field magnets and structure coils are as follows:

A cross between separate coils, or turns of a coil which are side by side, or cross each other.

When this occurs in magnets a portion of the coil is cut out, and its strength is diminished. A fault of this kind in the armature results in a loss of power, and possibly in burning out of the faulty coils.

A generator may still work with a large part of its field coils short circuited. Such a condition is shown by one magnet coil getting hotter than its mate, accompanied by sparking at the brushes.

Each coil of armature and each side of field magnet should be separately tested.

If a magnet coil is grounded at two points the current is shunted around a portion of the coil, as in the first case.

If two armature coils of considerable difference of potential are grounded on the core, they will probably be burned out, and in any event will reduce the power of the generator.

In either case the fault may be detected by testing the insulation of the coil. Each coil of armature must be tested separately.

The insulation resistance of the whole armature to ground may be first given.

In stations operated less than twenty-four hours per day, a careful test should be made for crosses or grounds before steam is turned on.

This test should be made sufficiently early to insure the correction of the trouble (should any be found) before the hour of starting the station.

In starting, the generators connected with the system should be run without pressure and gradually raised to proper E. M. F.; this will develop any fault originating since making test, and before any damage is done to either the system or apparatus.

The positive and negative sides of the system should be prominently indicated on all the conductors and electrical apparatus in the station.

A good plan to follow is for positive, use letter "A" in red; negative, use letter "B" in blue.

The electrical apparatus of the station should be so arranged that a circuit switch is provided for each generator.

This circuit switch should be used for throwing the generator in and out of circuit.

On C. S. generators a changing switch is mounted on the machine, and should not only be used for changing the generator over from one side of a three-wire system to the other, but should be used for throwing the generator in and out of circuit.

Each side of the switch should be prominently lettered to indicate respectively the "A" and "B" sides of the system.

OPERATING A PAIR OF GENERATORS IN SERIES.

Before starting up a pair of generators, inspect thoroughly every part, and have brushes, switches and connections in perfect order.

The engine should be gradually warmed and started a short time before the generators are needed, and kept turning slowly. They are then in readiness for instant use when needed.

If this precaution is omitted, trouble is likely to result in the hurry and confusion of a sudden demand for light.

The following order of procedure should be observed for starting up:

1. Fill oil cup and adjust feed. (If old style bearings are used.)

2. Get full speed on engine and armatures of both generators. Be sure that all switches are open, belts properly tightened, and everything in perfect order.

3. Adjust the brushes to both commutators. They should be in No. 3 position as shown on page 33.

4. Make sure that the fields of both generators are charged up properly. The strong attraction of a piece of iron will indicate that the field is made.

If a generator is thrown in multiple with other generators before its field is charged, a short circuit will be formed through its armature, and it may be burnt out.

5. Throw in generator galvanometer on first generator, and regulate pressure to the proper electro motive force.

One side of the generator galvanometer is connected to the neutral "Bus." The other side is connected to a switch, from which

wires are run to the neutral side of each generator, between the reversing switch and the brush. The galvanometer can thus be connected to any dynamo. When the pressure of the generator is the same as that of the circuit in which it is to be thrown, no current flows through the galvanometer, and it stands at zero.

5. Close the generator circuit switch. Care must be taken that it is done quickly.

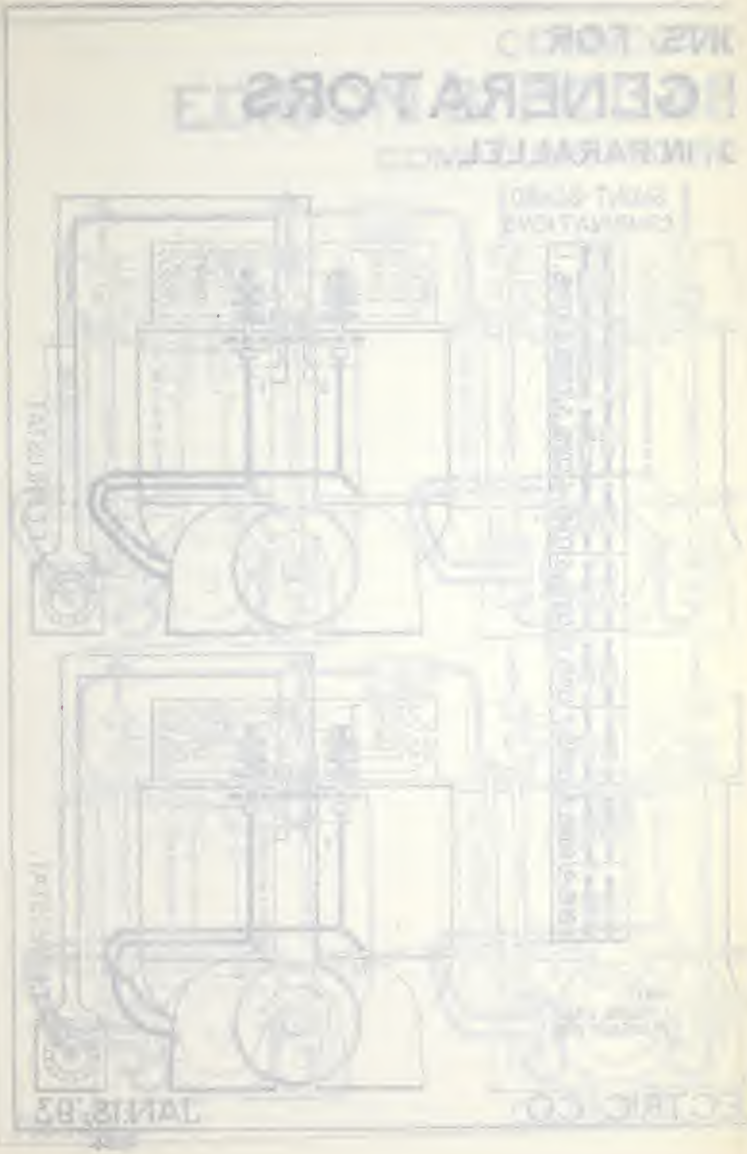
Adjust the brushes at once.

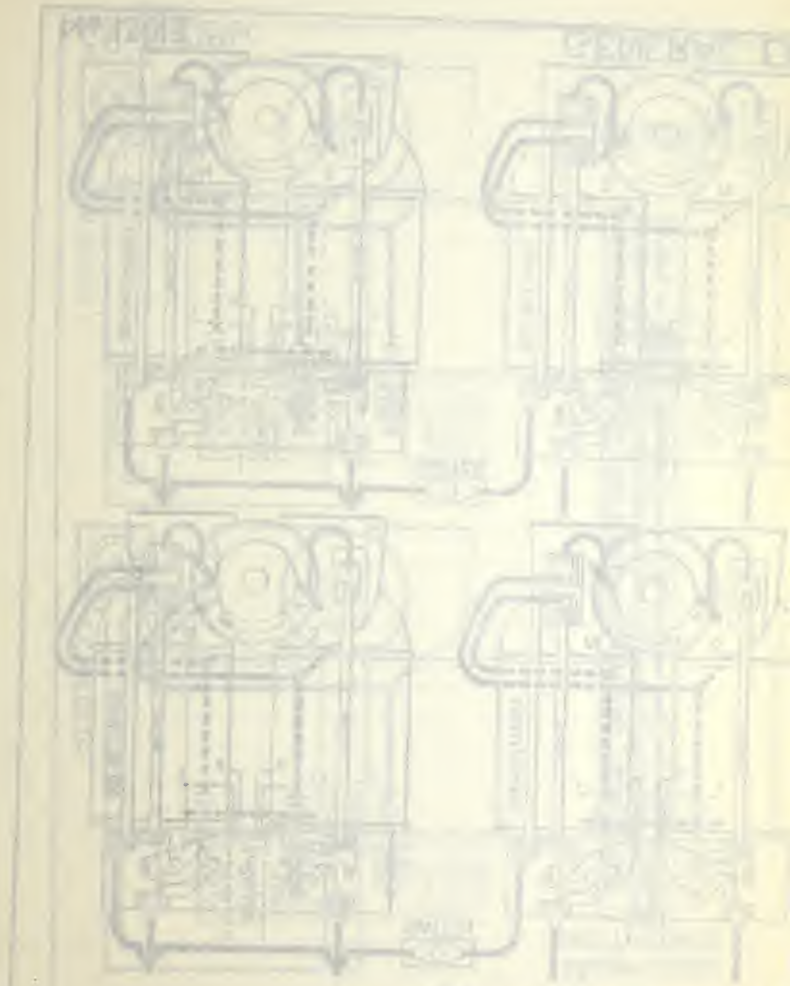
If a dynamo is of the same or nearly the same potential as every one of the others then there will be practically no change in ammeter or pressure indications on closing the switch, nor will there be any spark on making or breaking contact. The brushes will not need to be adjusted until the field of the machine just thrown in has been slightly strengthened and the field or fields of the machine or machines previously running on that side have been weakened. Repeat the last process which should be a gradual one, until the load is equally divided between all machines of that side of the system. Then switch in the machine on the other side of the system, following the same process. It is better to deal with one side before going to the other.

As the load gradually changes the brushes may require adjustment to the sparking point.

A generator should never be thrown on the station side of a pressure is exactly equal to that of the "live" circuit.

If a generator is thrown in multiple with other generators while in position it for the current in it would probably be reversed and it would run as a motor. It would then take current from the system, and increase the load upon the other generators instead of helping to carry it.





UNEQUAL DIVISION OF LOAD.

In the case of a pair of generators in series on the three-wire system, the division of load will depend on the balancing of the lights on the system, as well as on the pressure between the two sides. If pressures are all right an unequal division would indicate an unbalanced condition of the system which should be at once corrected.

If a generator is in multiple with another it may, if its pressure is too high, assume a portion of the load of the second generator, or even drive it as a motor. Overloading of the generator and heating of the armature is the result.

The obvious remedy is to regulate the pressure at once from the resistance boxes, by throwing resistance in the field of the first and throwing it out of the field of the second. This must be done very gradually.

When throwing a generator out observe the pressures on the system, and adjust the regulators of the remaining generators to keep the pressure at the proper point, also adjust all brushes to the increased load. The loads on both generators should be worked down together, and the second generator cut out as soon as possible after the first.

Generators should never be switched out on full load, except in case of extreme emergency.

The brushes should not be raised until the lamp on the headboard ceases to show incandescence. If this point is neglected the discharge of the field magnet coils may break the lamp, jump to base of machine or cause other trouble.

Having thrown out both generators, raise the brushes and clean and polish the commutators (if necessary) before stopping the engine in order to have them in readiness for the next run.

Shut down the engines slowly, and stop the oil feed.

The generators should then be thoroughly cleaned of oil, dirt and copper dust, and put in perfect order for the next run.

The engine should never be slowed down before the circuit switches are thrown out. Failure to observe this rule may result in burning out armatures.

Make sure that the open switches and lifted brushes are securely fixed in position against any chance of getting loose and unintentionally closing the circuit, which might result in serious damage.

IN SHUTTING DOWN FINAL PAIR OF GENERATORS.

In shutting down a system when only one pair of machines are running, shut down the engine and do not touch the resistance box. If this method be used there will be practically no sparking or adjustment of brushes required. Operate switches, and lift the brushes.

COMMUTATOR.

Special care and attention must be given to the commutator.

The perfect or imperfect condition of the commutator in a central station is strong evidence of the competency or incompetency of the attendants. There is a certain knack in caring for a commutator easily acquired by any careful and painstaking man.

Prevention, not cure, is the correct rule for commutator troubles. The life of a well cared for commutator should not be less than two years of **continuous** running, and maybe more. A little roughness is easily removed, but if allowed to increase it will soon be too late for any remedy except the lathe.

The commutator should at all times present a clean and polished surface and a true circumference. It is in its best condition when it presents a dark glazed surface, free from scratches. If accidentally scratched it may be polished with No. 00 sand paper moistened with a drop of sperm oil or vaseline, and cleaned with a piece of canvas or chamois skin. Emery paper or emery cloth should not be used to

scour the commutator, as the fine particles of emery, settling in the divisions between the bars, will cause short circuiting at the commutator. A file should not be employed except for special purposes.

Waste should not be used to clean the commutator, as the lint is apt to get under the brushes and cause sparking.

Avoid the use of all special kinds of grease or wax offered for sale for use on commutators; they do much more evil than good, and should not be permitted in the station.

If the commutator is but slightly rough or uneven or out of true, it may be ground down by the use of sand paper in a block hollowed out to fit its true circumference. If in very bad condition, however, it should be turned down with a tool and special rest made for the purpose.

For turning off commutators a slide rest can be obtained from the Schenectady Works and is made to attach to the generator bed. This will save removing the armature, provided a proper slow speed can be had. If an armature has to be removed for any cause the greatest pains must be taken in handling. Armatures are often burned out because of some blow or bruise received from careless handling.

Do not lay an armature on the floor unless some sort of cushion is placed underneath. Armatures should be lifted and carried by the shaft as far as possible.

In turning off commutator the cut should stop before reaching the end of the bar. This is important to preserve the insulation and to keep the iron collars intact for receiving a new set of bars.

The amount of wear on commutator which may be allowed before sending to shops for repairs depends on the depth of the commutator bars, and the amount of current they are required to carry. This varies in different machines.

The safe depth to which the commutator may be worn in each machine should be known, and a new commutator supplied before the dangerous point is reached.

The following table shows the original diameters of commutators and the diameters to which they may be safely worn for different sizes of generators:

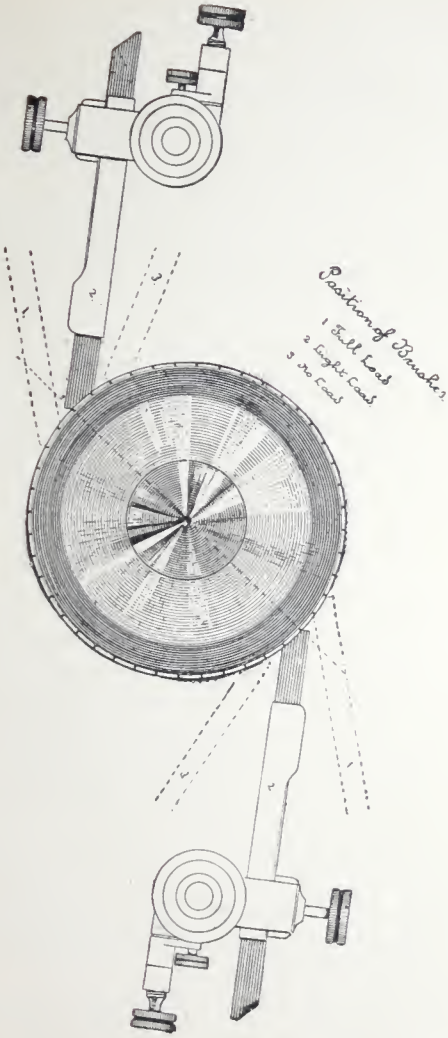
COMMUTATORS FOR EDISON BIPOLAR DYNAMOS.

'85 TYPE, 125 VOLTS.

KILOWATTS.	NUMBER OF BARS.	LENGTH OVER ALL.	LENGTH OF BRUSH SURFACE.	DIAM. OF BORE OF SHAFT.	OUTSIDE DIAM. OF COMMUTATOR.	ALLOWED FOR TURNING DOWN	LEAST SAFE DIAM. OF COMMUTATOR.
.5	32	2	$\frac{5}{8}$	$\frac{9}{16}$	2	$\frac{5}{16}$	$1\frac{3}{4}$
.75	42	$3\frac{3}{32}$	$1\frac{1}{4}$	$\frac{7}{8}$	$2\frac{1}{4}$	$\frac{5}{16}$	$1\frac{3}{4}$
1.5	52	$3\frac{1}{4}$	$2\frac{1}{4}$	$\frac{7}{8}$	$2\frac{1}{2}$	$\frac{5}{16}$	$1\frac{3}{4}$
3	44	$4\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{1}{4}$	$3\frac{3}{8}$	$\frac{7}{16}$	$2\frac{1}{32}$
6	56	$5\frac{1}{2}$	$2\frac{5}{8}$	$1\frac{3}{4}$	$3\frac{1}{2}$	$\frac{1}{2}$	$2\frac{3}{8}$
8.5	48	$5\frac{1}{2}$	$2\frac{5}{8}$	$1\frac{1}{2}$	$3\frac{5}{8}$	$\frac{15}{32}$	$2\frac{1}{32}$
12	50	$5\frac{1}{16}$	3	$1\frac{1}{4}$	$4\frac{1}{2}$	$\frac{9}{32}$	$3\frac{3}{16}$
15	48	$7\frac{1}{4}$	$4\frac{7}{8}$	$2\frac{1}{8}$	$4\frac{13}{16}$	$\frac{3}{8}$	$3\frac{9}{16}$
20	60	$8\frac{1}{4}$	$5\frac{1}{4}$	$2\frac{3}{4}$	$5\frac{1}{4}$	$\frac{3}{8}$	4
25	66	$8\frac{1}{4}$	$5\frac{1}{4}$	$2\frac{3}{4}$	$5\frac{13}{16}$	$\frac{21}{32}$	$4\frac{1}{2}$
30	58	$8\frac{1}{4}$	$5\frac{1}{4}$	$2\frac{3}{4}$	$6\frac{5}{16}$	$\frac{1}{2}$	$4\frac{13}{16}$
45	52	$9\frac{1}{2}$	$5\frac{3}{4}$	$3\frac{1}{2}$	$6\frac{13}{16}$	$\frac{11}{16}$	$5\frac{7}{16}$
60	50	$9\frac{1}{2}$	$5\frac{3}{4}$	$3\frac{1}{2}$	$6\frac{7}{8}$	$\frac{11}{16}$	$5\frac{1}{2}$
100 140 volts	48	$13\frac{3}{4}$	$8\frac{1}{4}$	$4\frac{1}{2}$	$9\frac{5}{16}$	$1\frac{5}{32}$	$6\frac{3}{4}$
150 140 volts	41	$21\frac{1}{4}$	$15\frac{3}{4}$	6	$12\frac{1}{2}$	$1\frac{3}{4}$	$9\frac{1}{4}$

It is assumed that the diameter is kept the same for the whole length of the commutator, and that the section of the bars at the dangerous point is just equal to the section of the wire of the armature.

It sometimes happens that a bar in the commutator will spring up and stand a little higher than the rest. This will cause the brush to vibrate, and occasion sparking on account of imperfect contact. The generator should be stopped as soon as possible, and the high bar carefully filed down to a true circumference.


Position of Brusher
1 Full Load
2 Light Load
3 No Load
1
2
3

THE NEUTRAL POINT.

The neutral points of a generator are those positions on the commutator between which the difference of potential is the greatest and where there is the least difference of potential between adjacent bars. These points are diametrically opposite.

The position where there is no sparking of the brushes, or the non-sparking point, does not exactly coincide with the neutral point when there is a load on the machine. The non-sparking point advances faster than the point of highest electro-motive force, and they are further apart the greater the load.

The neutral point changes with the change of load. With a slight load the neutral point is near the extremities of a horizontal diameter. As the load increases the neutral point moves forward in the direction of rotation, and the brushes must be advanced to the non-sparking point.

ADJUSTMENT OF BRUSHES.

In order to maintain the commutator in proper condition and reduce the wear to a minimum, it is vitally necessary that a proper adjustment of the brushes be secured. They should work absolutely free from sparks. Any sparking whatever indicates a bad condition of the commutator or defective adjustment of the brushes.

Woven wire brushes can be used in the standard brush-holder by removing the trough and stiffening the brush with strips of hard copper, called "brush guides."

The brushes should be firmly fastened in the holders in order to insure good conductivity and avoid heating, and placed at the proper angle to secure the best contact surface.

The end of the brush should be carefully beveled so as to conform accurately with the surface of the commutator. The brush should bear lightly upon the commutator, and every part of the

beveled end should rest upon it. The pressure should be just sufficient to insure good contact and avoid all cutting and scratching.

One of the worst causes of sparking is lack of pressure of the brush on the commutator, caused by improper setting of the brush holder stud or by allowing a brush to wear too short. The proper angle of the end of the brush is about 45 degrees. To maintain this as the brush wears it must be pushed forward in the holder from time to time. If this is not attended to, the brush holder will be held up on the stop pin, pressure is relieved and imperfect contact or none at all is the result.

When at rest the brushes should always be raised from the commutator, and held away by the clips provided for the purpose.

If left in contact with the commutator they are liable to be injured or perhaps ruined by an accidental reversing of the direction of rotation.

The ends of the brushes, where they rest upon the commutator, should not be allowed to become dirty, rough or ragged, nor should the strands be allowed to spread.

The brushes should at frequent intervals be removed, edges trimmed, ends filed and reset.

They may be cleaned from oil by washing in benzine.

Bipolar generators can be operated under full load with absolutely no spark at the brushes.

It is very necessary that persons in charge of generators fully appreciate this fact, and always aim to secure this condition of operation.

A generator in operation with a spark at brushes is *prima facie* evidence of carelessness or ignorance on the part of the attendant, and no central station manager should tolerate such a condition of affairs or accept any excuse whatever for its continuance.

COPPER WOVEN WIRE BRUSHES.

EDISON BIPOLAR.

CLASS.	Length.	Width.	Thickness.	Angle of Bevel.	Number of Brushes		Catalogue Number	
					On Each Stud.	Per Machine.	Brushes.	Brush Filing Jig
.5 Kw.	3	$\frac{5}{16}$	$\frac{5}{32}$	45°	1	2	57111	57206
.75 "	$4\frac{1}{2}$	$\frac{3}{8}$	$\frac{13}{64}$	45°	2	4	57112	57207
1.5 "	$4\frac{1}{2}$	$\frac{3}{8}$	$\frac{13}{64}$	45°	2	4	57112	57207
3 "	7	$\frac{7}{16}$	$\frac{5}{32}$	45°	2	4	57113	57208
6 "	7	$\frac{7}{16}$	$\frac{5}{32}$	45°	2	4	57114	57209
8.5 "	7	$\frac{7}{16}$	$\frac{5}{32}$	45°	2	4	57114	57209
12 "	7	$\frac{7}{16}$	$\frac{5}{32}$	45°	2	4	57114	57209
15 "	9	$1\frac{1}{16}$	$\frac{11}{32}$	45°	2	4	57115	57210
20 "	9	$1\frac{1}{16}$	$\frac{11}{32}$	45°	2	4	57115	57210
25 "	9	$1\frac{1}{16}$	$\frac{11}{32}$	45°	2	4	57115	57210
30 "	9	$1\frac{1}{16}$	$\frac{11}{32}$	45°	2	4	57115	57210
45 "	9	$1\frac{1}{16}$	$\frac{11}{32}$	45°	2	4	57115	57210
60 "	9	$1\frac{1}{16}$	$\frac{11}{32}$	45°	3	6	57116	57211
100 "	12	$1\frac{1}{16}$	$\frac{3}{8}$	45°	3	6	57117	57212
150 "	12	$1\frac{1}{16}$	$\frac{3}{8}$	45°	6	12	57117	57212
200 "	12	$1\frac{1}{16}$	$\frac{3}{8}$	45°	6	12	57117	57212

COPPER WIRE BRUSHES.

Kw.		.5	.75	1.5	3	6	8.5	12	15	20	25	30	45	60		100		150
														125v	500v	140v	500v	140v
Number of Brushes.	On each Stud.	1	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	6
	Per Machine.	2	4	4	4	4	4	4	4	4	4	4	4	6	6	6	6	12
Number of Prongs.		1	1	1	1	2	2	2	3	3	3	3	3	2	2	3	3	3
No. of Layers Beveled.	125v.	3	4½	4½	4½	4½	4½	4½	6	6	6	6	6	9		9		9
	500v.							4½	4½	4½	4½	6	6		5		6	
Thickness.		5/32	13/64	13/64	7/32	7/32	7/32	7/32	1 1/32	1 1/32	1 1/32	1 1/32	1 1/32	7/32	9/32	5/8	1 1/32	5/8
Width.		7/16	3/8	3/8	27/64	1 5/8	1 5/8	1 5/8	1 13/16	1 13/16	1 13/16	1 13/16	1 13/16	1 5/16	1 5/16	1 13/16	1 13/16	1 13/16
Length.		3	4½	4½	7	7	7	7	8	8	8	8	8	9	9	12	8	12
Brush Filing Jig Catalogue No.					57200	57200	57200	57200	57203	57203	57203	57203	57203	57201	57202	57204	57203	57204

Before starting up, the brushes must be adjusted so that their ends rest on the commutator at diametrically opposite points. Opposite bars of the commutator can be found by counting them.

Table Giving Number of Sections in Commutators of Different Sizes of Generators.

Kw.	3	6	8.5	12	15	20	25	30	45	60	100	150
Sections.	44	58	48	50	48	66	66	58	52	50	48	41

As a result of the brushes not being diametrically opposite, it will be impossible to get them both exactly on the neutral point, and a spark will be produced.

Sparking at the brushes results from a variety of causes.

Sparking is expensive and detrimental chiefly because it results in burning the brushes and commutator, hastening their frequent renewal. Every spark consumes a particle of copper, torn from the commutator or brush. The longer the sparking continues the greater the evil becomes, and the remedy must be applied without delay.

SPARKING, CAUSES AND REMEDIES.

1st C. Brushes not set at neutral point.

R. The brushes having been previously set diametrically opposite, they can be readily adjusted to the neutral point by moving the rocker arm backward or forward until the non-sparking point is found.

2d C. Brushes not set at diametrically opposite points.

R. Great care must be taken to have the brushes set diametrically opposite before starting, as their readjustment while running is troublesome. If any individual brush sparks while the other brushes are working perfectly, it is out of alignment.

To adjust, shift brush in holder until non-sparking point is reached.

3d C. Brushes set so as not to get full bevel to the circumference of commutator.

R. If brushes are set crooked, and do not bear evenly on the commutator, sparking is apt to result. Readjustment must be made to secure full face of brush at proper bevel.

4th C. Brushes set with insufficient pressure.

R. This fault can often be remedied by increasing tension on spring in brush holder.

If all brushes on same side have too little pressure, loosen large nut on end of brush-holder bar and turn bar slightly toward commutator, tighten nut firmly and give careful attention to adjustment of spring. This can be done when generator is stopped.

5th C. Brushes spread apart and filled with dirt and oil.

R. Oil and copper dust and dirt will fill in between the wires and spread the brushes. All this can be removed by a thorough washing in benzine or a hot solution of sal-soda water, or strong potash water. With proper care this will not require to be done oftener than once a week.

6th C. Brush having loose or crooked wire on edge.

R. Loose or crooked wires on edge of brushes are usually caused by careless management in putting brush in holder.

If this trouble occurs accidently while in operation, carefully bend the loose wire back and clip it off close to the body of the brush.

Any loose wire causing sparking should be removed.

7th C. Brush with hard burnt ends, which destroy its pliability and increase the resistance at contact with the commutator.

R. Brushes, if so badly burned that pliability is lost, must be thrown away; but, if still pliable and of sufficient length, cut off the burnt portion and file to proper bevel in the brush filing jig.

8th C. Commutator bars loose, high or low.

R. A single high bar in the commutator will vibrate the brush, causing poor contact, and consequent sparking. A heavier

tension must be applied to the spring of the brushes until the run is over. As soon as possible the generator should be stopped and the high bar carefully repaired.

If commutator bars are loose, screw up the ring at end of commutator.

If bar is high, set it down in place with a wooden mallet and screw up the ring.

If bar is low, screw the ring up firmly in place and turn the commutator down to a true circumference, or grind it down with sand paper in a hollow block.

9th C. Loose connection between armature coil and commutator bar.

R. A loose or broken connection between commutator and armature coil will cause a peculiar blue snapping spark, just as the bar leading to it is passing under the brush.

This will show itself on the particular bar having the loose connection.

This spark cannot be wholly remedied while running. The spark may be diminished by setting one brush on each side a little in advance of the other. The generator should be stopped as soon as possible and the connection of the armature carefully examined and any loose joints properly repaired.

Take off covering over connections, loosen screws holding connections together.

See to it that the soldering on joint is thoroughly sweated in, and the little pocket holding ends of wire is filled with clean solder making a perfect joint.

Clean all surfaces, tighten up screws firmly, and renew canvas covering over end of armature.

Be sure that this covering is always strong and whole, do not permit it to get ragged and let in copper dust.

10th C. Section short circuited, either in commutator or armature coils.

R. This fault cannot be repaired in station unless there is an expert man on hand who knows how to wind an armature. The armature will probably require to be sent to district office for repairs.

11th C. Armature damp, with consequent short circuiting of coils.

R. A damp armature can generally be dried out by setting it near a stove or steam radiator, where it will be exposed to moderate heat.

12th C. Short circuit or cross on outside system.

R. A cross will cause brushes to spark and sputter severely. The cross must be burnt out promptly.

13th C. Commutator dirty, oily, rough, worn in ridges, or out of true circumference.

R. Oil and dirt can be wiped off with a piece of canvas or chamois; then polish commutator with fine sand paper. Ridges should be scoured down with sand paper. A commutator out of true should be turned down with a tool and slide rest, using a slow speed and a fine cut (see special instructions, page 30).

14th C. Generator overloaded.

R. This cause of sparking is easily detected at the ampere meter. The proper measures should be taken at once to relieve the machine. If the load on a pair is unequally divided, it should be properly regulated by means of the resistance boxes. If due to a heavy load of lamps, or short circuit on the line, the overloaded generator can be relieved by throwing an additional generator in multiple arc with it.

As an ampere meter is not infallible it is well to notice the temperature of the armature, if a generator is doing heavy duty.

The test of temperature can be made by laying a glass thermometer close against the armature immediately on stopping the generator; cover the thermometer with a piece of clean waste to avoid effects of outside temperature, leave it in contact for about five minutes and note temperature quickly on removal.

one° Cent. (1+1° F.) is the maximum temperature.

If the lamps connected on the system are so great in number as to cause an overload of all the generators every night, then an additional pair of generators should be ordered at once.

15th C. Armature coils or commutator sections short circuited by accumulations of copper dust.

R. An examination of some generators would lead a man to believe the machine was constructed for the purpose of producing copper dust.

The accumulation of copper dust on a generator and its gradual penetration into the coils of armature and fields, is often the real cause of serious accident and expensive repairs.

This is one of the principal features which denotes carelessness and inefficient management, and an utter lack of appreciation of the importance of cleanliness about generators and electrical apparatus.

The remedy is easy to apply: the generators MUST be kept clean of oil and copper dust.

Should the operator not be perfectly familiar with the work outlined in any of the remedies suggested in the foregoing, he should not undertake it, but return the apparatus to the nearest repair shop of the General Electric Company, where proper facilities are at hand for doing such work.

FAULTS AND ACCIDENTS.

It is only in times of accident that we develop in a central station superintendent some of the most necessary qualifications for this work, or that his inability is made manifest. Presence of mind, calm judgment, quick action — all combined — enabling him to do just the right thing in an emergency on the spur of the moment, are all important.

When accidents happen in an electric light station they come quick, and no time is to be lost in applying the proper remedy.

Experience and perfection of system have enabled us largely to avoid troubles which in early days were of frequent occurrence.

The faults and accidents to which generators are liable are very rare, and may be largely avoided by careful inspection and proper care. When accidents occur, the cause must be quickly perceived and the remedy intelligently applied.

The following are some of the disorders:

BURNING OUT ARMATURE COIL.

This may be occasioned by overloading the armature, causing the insulation of the coils to give way, and is indicated by the armature suddenly beginning to smoke. The coil is thus rendered useless. As a temporary makeshift, the injured coil may be disconnected from the commutator, the ends insulated with tape, and the two adjacent bars to which the coil was connected, joined to each other by a wire not smaller than the armature wire.

The machine can be operated for a time in this way, but a new armature should be put in as soon as possible.

RING OF FIRE AROUND THE COMMUTATOR.

This is caused by small particles of copper betweeen the bars of the commutator, making a local short circuit from bar to bar across the mica insulation.

To remedy it, clean the commutator carefully, and do not allow the brushes to cut and scratch it.

BREAKING DOWN OF ONE GENERATOR.

If one generator of a single pair operating on a three wire system breaks down from any cause, the break down switch should at once be thrown, providing the total number of lamps burning does not exceed the capacity of the remaining generator, which will then be supplying current for those lamps on, practically, a two-wire system. Should the total number of lamps burning exceed the

capacity of the remaining generator, those on the side of the disabled generator must be thrown off, the remaining generator simply supplying current to its own lamps. In this event, the break-down switch will not be used.

In any case the disabled generator should be thrown off the system at once.

REVERSAL OF POLARITY OF MAGNETS.

Reversal of polarity of a generator which is one of two or more connected in multiple is equivalent to a dead short circuit, and, if it does not blow a fuse or throw off a belt, will probably burn out an armature.

Reversal of polarity of one of a single pair of generators working in series on a three-wire system will tend to send all the current through the neutral wire, which will cause the lights to burn dim, and charge up the current to the company on all meters on the reversed side.

If the reversed generator should be switched in with another not reversed on the same side further trouble is caused. If generators supplying current through meters should all be reversed, the meters will all be caused to read backward.

Any man having a generator under his care, should be perfectly familiar with the proper methods of charging a reversed or demagnetized field.

A compass for testing polarity can be had for a small sum. In an emergency a magnetized steel needle attached to a silk thread will answer every purpose. Do not trust to the mark on the compass, but see for yourself which way it points, and remember that the north pole of the compass points to the south pole of the generator.

Generators on the three-wire system may be reversed under the following conditions:

A reversal of the polarity of the field magnets sometimes takes place when starting up.

This may be due to the influence of another generator in close proximity to it.

The induction of a strong magnet may be sufficient to reverse the slight permanent magnetism of the generator at rest.

THE FIELD OF A GENERATOR MAY BE REVERSED:

By the current of a second generator in series with it while in operation, if the brushes of the first generator are accidentally raised or its current broken in any way between the points to which the field circuit is connected.

By lifting the brushes before throwing out the switch.

By burning out the safety catches which are on some of the old style generators.

By crosses on the lines.

By 200 volt motors. This is more apt to occur during a light load, when the motor is thrown on with a heavy load.

If one side of the system becomes reversed, it will show the fact by low pressure and by the indicators on that side reversing, and by the neutral "bus" becoming very hot and the neutral ampere meter indicating a very heavy load; also, no difference of potential between + and — "bus."

To correct the machines open the circuit switch, raise the brushes and throw the generator-changing switch on the side not reversed, and leave it about a minute. Then, after raising the field on it, test the polarity of the machine with test paper, or by the methods mentioned on page 44.

EFFECTS OF LIGHTNING.

Lightning is to be feared as a property-destroying agent merely. One of the safest places to be in during a thunder storm is an electric light station. Where damage has happened to a generator caused by lightning, the occasion has been found in the absence of the proper safeguards or in some faulty work in connection with them.

No effects of lightning will be felt on Edison systems with street conductors entirely underground. Where there are very long outdoor pole lines similar effects occur as on telegraph and telephone lines, and somewhat similar precautions should be taken to prevent injury to apparatus.

The usual result of lightning freaks are the breaking of lamp carbons, melting of fuses, and damaging of generators, by injury to the insulation or reversing and demagnetizing.

For the protection of the generator in systems having long overhead lines special precautions should be taken in the way of perfectly insulating the base from the ground. Direct connection of water or drip pipes to the generator is to be avoided, and even the proximity of such pipes, when lightning is specially to be guarded against, is objected to. Lightning arresters, when used, should be in plain sight. Fuses on such arresters must be promptly replaced. Ground wires and connections are particularly important and must be kept intact and in good condition.

The following will always guide you in recharging a generator:

I.—Raise the brushes of the demagnetized or reversed generator.

II.—By the double changing switch throw it in multiple arc with one which is running all right on the other side of the system.

III.—Close the single generator switch for an instant.

This does not take over thirty seconds.

The previous instructions given for tests of field and armatures for crosses and grounds, and also for demagnetization and reversal of polarity fully cover the important points for immediate investigation of damage and the proper remedy to apply.

CROSSES ON STREET CONDUCTORS.

These troubles are not of frequent occurrence and principally happen on overhead systems, due to severe storms causing the dropping of telephone or telegraph wires across the electric light circuits.

It is estimated that all crosses can be prevented by the use of wire having durable weather proof insulation, and by careful and

thorough construction of the pole line system. Nevertheless, the fact remains (in the absence of these precautions, in many cases due to lack of original investment) that crosses occur, and it therefore becomes our duty to give such instructions as will enable the station operator to clear his lines and thus avoid more serious damage.

In this particular the operators must work with promptness and decision.

When a leak appears on the system, whether a ground or a cross, additional generators must be thrown in on the faulty side. As much current as possible must be forced into the leak, in order to burn out the fault or safety fuses, if possible, and to keep the lights up to candle power.

The fault should then be located and corrected at once.

If a heavy cross or ground shows on the line, and the lights burn low or go out, vigorous measures must be taken at once. Such a fault usually occurs when there is a light load on the system, and insufficient current being generated to melt the safety fuses.

To clear out the cross, start up two or three generators, and get their pressures up until the pilot lamps show somewhat less than full candle power.

The changing switches should be so adjusted as to throw all the generators on the faulty side.

Then everything being in readiness, at a given signal close all the circuit switches. At the same instant the rocker arms should be pulled over and the brushes adjusted. To achieve success, the men must act in unison and quickly.

If the fault is not cleared, the generators must be thrown out and the operation repeated with more generators.

The above described method is usually successful in clearing the fault or fusing the nearest safety catches, after which the lights on that side will come up again.

CAUTION.

Great care must be taken, when the fault disappears, that the pressure on the system does not come up too high and injure the lamps.

FACTS TO BE REMEMBERED.

1. Be sure that the speed of the generator is right.

2. Be sure that all the belts are sufficiently tight.

3. Be sure that all connections are firm and make good contact.

4. Keep every part of the machine and generator room scrupulously clean.

5. Keep all the insulations free from metal dust or gritty substances.

6. Do not allow the insulation of the circuit to become impaired in any way.

7. Keep all bearings of the machine well oiled.

8. Keep the brushes properly set and see to it that they do not cut or scratch the commutator.

9. If the brushes spark, locate the trouble and rectify it at once, AS NO EXCUSE WILL BE ACCEPTED FOR SPARKING.

10. The durability of the commutator and brushes depends on the care exercised by the person in charge of the generator.

11. At intervals the generators must be disconnected from the circuit and thoroughly tested for leakage and grounds.

12. In stations running less than 24 hours per day, the circuit should be thoroughly tested and grounds removed (if any are found) before current is turned on.

13. Before throwing generators in circuit with others running in multiple, be sure the pressure is the same as that of the circuit, then close the switch.

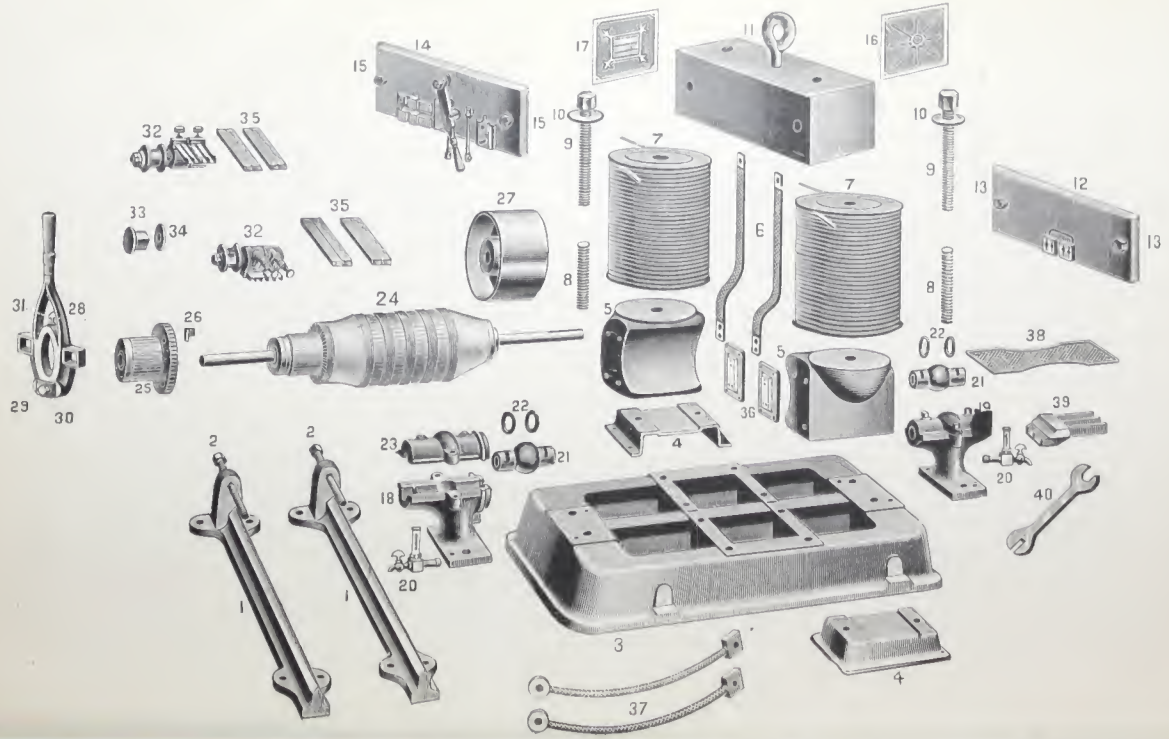
14. Be sure each generator in circuit is so regulated as to have its full share of load, and keep it so by use of resistance box.

Each central station manager is advised to drill his subordinates (as far as possible) in all the foregoing details, so as to make them prompt in action and less liable to error in case of emergency.

For further instruction or information please address the nearest office of the Company.

EDISON BIPOLAR GENERATORS.

CONNECTIONS FOR
COMPOUND WOUND.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40

LIST OF PARTS, EDISON GENERATOR, "1885 TYPE."

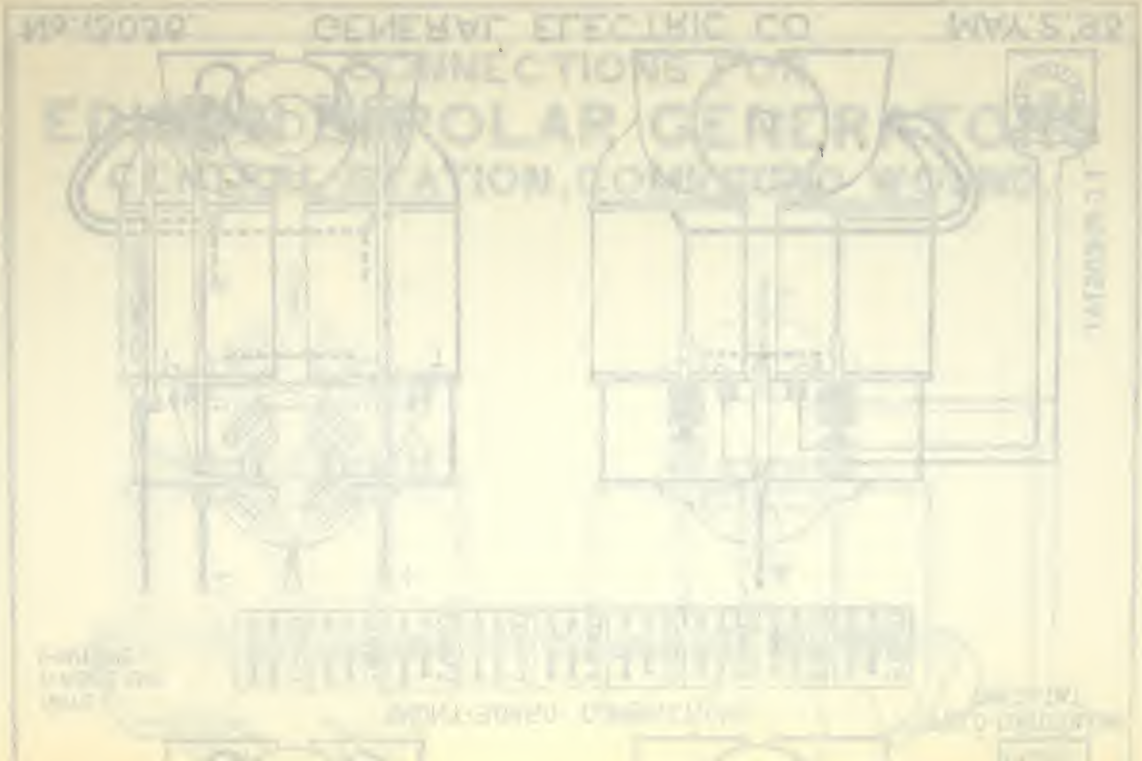
1. Rails.
2. Adjusting Rail-Bolts.
3. Bed-Plate.
4. Zinc Bases for Fields.
5. Pole Pieces.
6. Conductor Rods.
7. Field Coils and Cores.
8. Lower Screws, field cores to pole pieces.
9. Bolts for attaching keeper to pole pieces.
10. Washer for same.
11. Keeper.
12. Blackboard and field coil terminal blocks.
13. Bolts for same.
14. Head-board.
15. Bolts for same.
16. Rib Side-Plate.
17. Panel Side-Plate for Name-plate.
18. Pillow Block Case. Commutator End.
19. Pillow Block Complete, Pulley End.
20. Drip Cock for self-oiling bearings.
21. Bearing Sleeve for self-oiling bearings.
22. Rings for self-oiling bearings.
23. Cap for Pillow Block. Commutator End.
24. Armature complete.
25. Commutator complete.
26. Comt. Cap for ends of Armature coils.
27. Armature Pulley.
28. Brush Yoke.
29. Bolt for same.
30. Spring Washer for adjusting tension.
31. Thumb Screw for Yoke.
32. Brush-Holder Complete.
33. Insulating Blocks for Brush-Holder.
34. Insulating Washer for Brush-Holder.
35. Brushes.
36. Foot-Boards.
37. Brush-Holder Cables.
38. Wire Screen for protecting Armature.
39. Brush Filing Jig.
40. Generator Wrench.

CENTRAL STATION, COMMONWEALTH EDISON COMPANY, CHICAGO

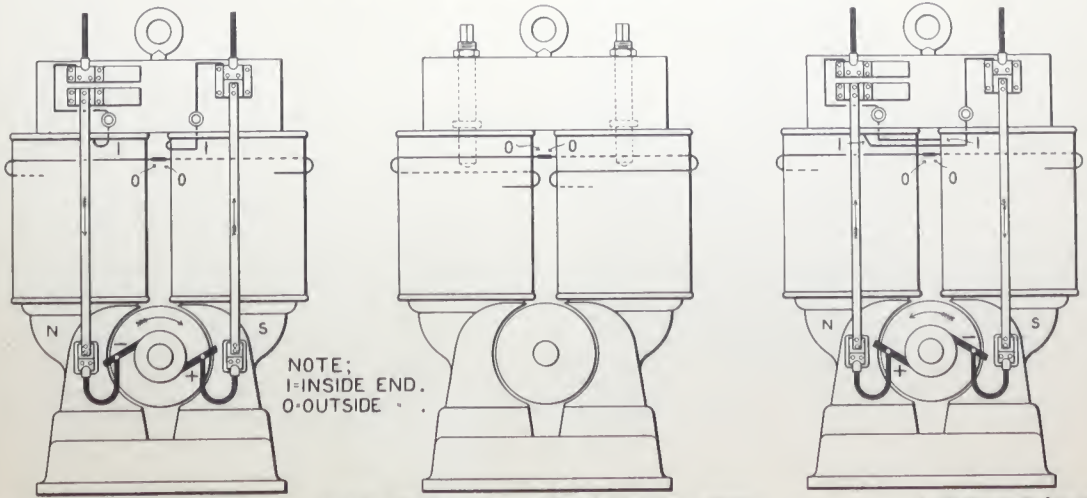
EDISON BIPOLAR GENERATORS

CONNECTIONS FOR

No.13055. GENERAL ELECTRIC CO. APR.28.'93.



CONNECTIONS FOR
·5, ·75 AND 1·5 K.W. GENERATORS
KEEPER REGULATION.

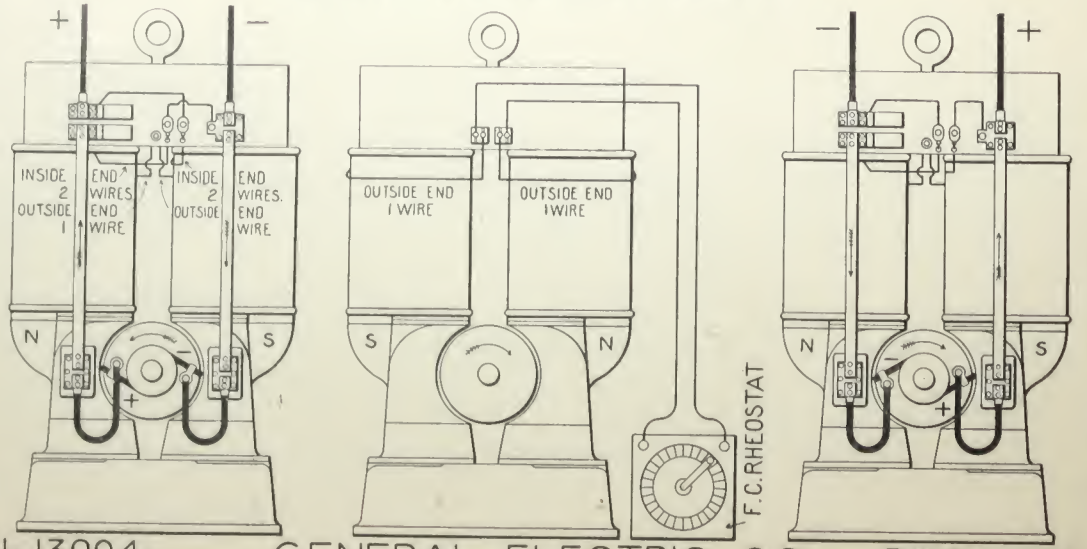


No.13055. GENERAL ELECTRIC CO. APR.28,'93.

CONNECTIONS FOR

EDISON BI-POLAR GENERATORS

SHUNT WOUND. 125 VOLTS.

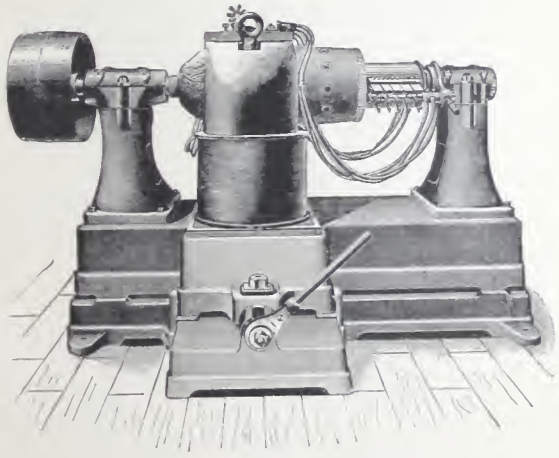


No. 13004. GENERAL ELECTRIC CO. DEC 14, '92.

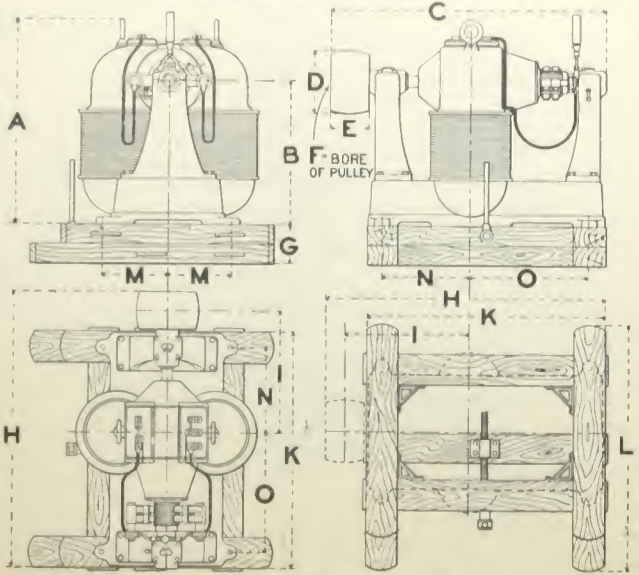
TYPE D AND SPHERICAL INCANDESCENT GENERATORS.

The directions given in the preceeding pages will apply in large part to the installation and operation of the "D" and Spherical Incandescent Generators.

The accompanying diagrams and illustrations show the features of these machines which are not common to the Edison bipolar machines.



TYPE D GENERATORS
CLASSES 2 TO 15



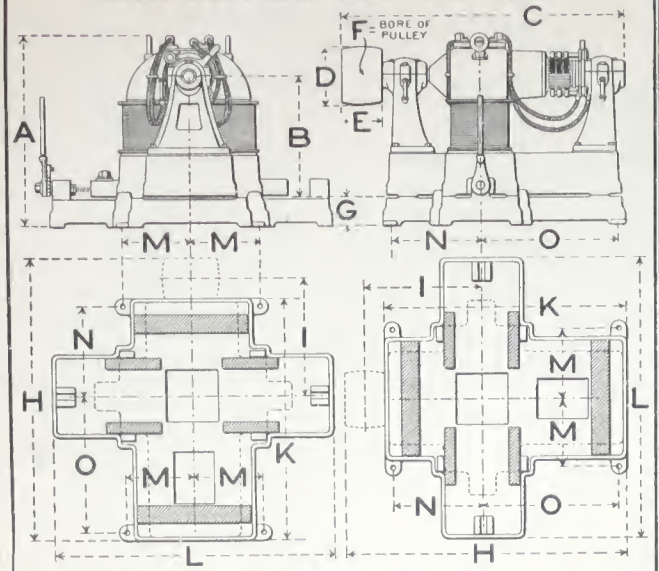
CLASS	2	3	5	7½	10	15
NET WEIGHT*	340	530	720	1120	1490	2000
WEIGHT OF WOOD BED PLATE	45	45	50	60	90	110
KILOWATTS	2	3	5	7½	10	15
HORSE POWER TO DRIVE	3	4½	7½	11½	15	22½
SPEED	2500	2400	2000	1600	1600	1400
A	18 5/16	20 7/16	23¾	26½	28 7/16	32⅝
B ⊘	13 9/16	14	16 9/16	18 15/16	20 1/16	23 3/16
C	23 15/16	29¼	30 1/16	36 15/16	40¼	44⅛
D ⊘	4	5	6	8	8	10
E	2	3	4	5	6	7
F ⊘	1	1⅛	1⅛	1⅜	1¾	1⅞
G	5 3/16	5 3/16	5 3/16	5 3/16	5 3/16	5 3/16
H	23⅜	28⅝	30½	36 15/16	40½	44 3/16
I	10 1/16	12¾	12⅝	16 1/16	17⅜	19⅜
K	21⅛	25	26⅝	31⅞	35	37½
L	28½	24½	30	33¼	37	40½
M	6½	6⅜	7 1/16	8 3/16	9	10⅛
N	6⅞	8⅞	8 7/16	11 1/16	12 3/16	13¼
O	10¾	12⅝	13 5/16	15 15/16	17½	18⅜

* WITHOUT BED PLATE. App H.G. Reist

⊘ EXACT; ALL OTHER DIMENSIONS APPROXIMATE.

No. 3618 General Electric Co. Jan. 2, 1893

TYPE D GENERATORS
CLASSES 20 TO 90



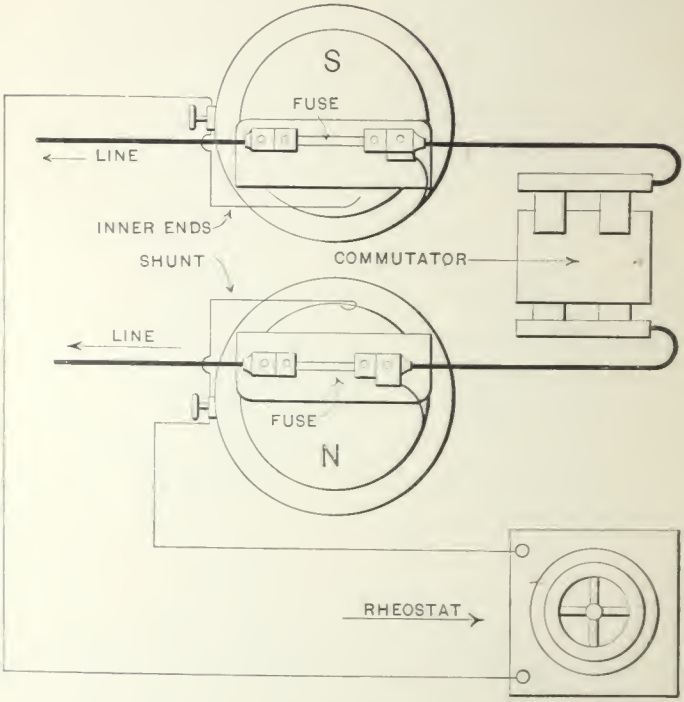
No. 3617. General Electric Co Jan 2'93

CLASS	20	25	30	40	50	62	90
NET WEIGHT*	3100	3675	4825	6325	7300	10325	15775
WEIGHT OF IRON BED PLATE	690	900	1050	1850	2150	2220	2720
KILOWATTS	20	25	30	40	50	62	90
HORSE POWER TO DRIVE	30	38	45	60	75	93	135
SPEED	1300	1225	1170	1125	1020	900	750
A	36 5/8	36 5/8	39 1/2	43 3/8	46 3/8	53 1/2	58 7/8
B ◦	26 5/8	25 3/4	29 1/4	32 3/8	34 1/4	39 3/8	43 3/8
C	58 5/8	62 3/8	66 1/4	75 5/8	81 5/8	90 1/8	105 1/4
D ◦	13 1/2	14	14 1/2	15 1/2	17	19	23
E	9	9	10	11	12	13	14
F ◦	2	2 3/16	2 7/16	2 3/4	2 15/16	3 7/16	3 13/16
G	5 1/4	6	6 1/2	7 1/2	7 1/2	9 3/8	9 1/8
H	60 7/16	63 3/16	67	75 5/8	81 7/8	91 1/8	109 1/4
I	25 13/16	26 3/4	27 5/8	31 9/16	34 11/16	38 11/16	44 1/2
K	50 11/16	54	57 1/2	66 1/16	69 5/8	77	96
L	49 13/16	61 1/4	67 1/4	76 3/16	77 13/16	88 5/8	93
M	15 1/4	15 5/16	16 5/16	18 5/8	19 1/2	20 5/16	23 7/8
N	19	20 3/4	20 7/8	24 7/8	25 1/2	28 1/2	33 1/2
O	28 1/2	30 3/4	32 5/8	36 5/8	38 3/4	43	53 1/2

*WITHOUT BED PLATE. App. J.H.S. Reist

◦EXACT; ALL OTHER DIMENSIONS APPROXIMATE.

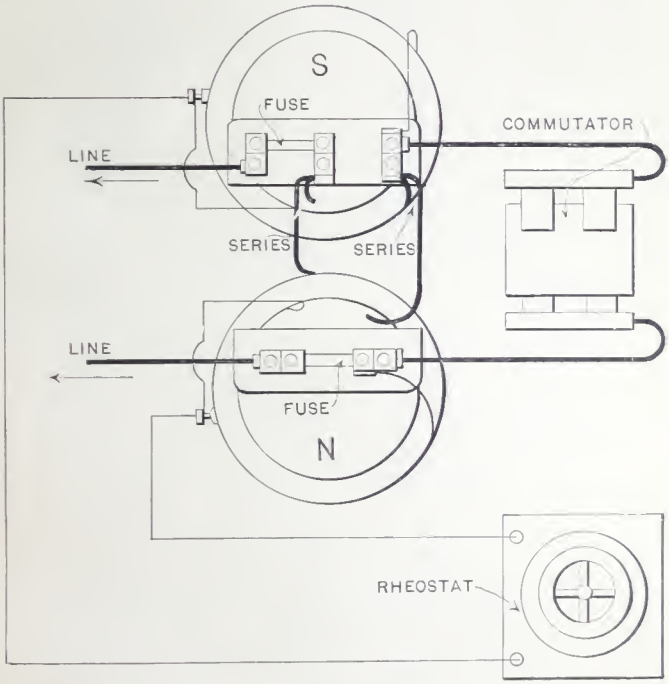
CONNECTIONS OF D-2, D-3, D-5, D-7½, D-10, D-15 SHUNT GENERATORS.



GENERAL ELECTRIC CO.

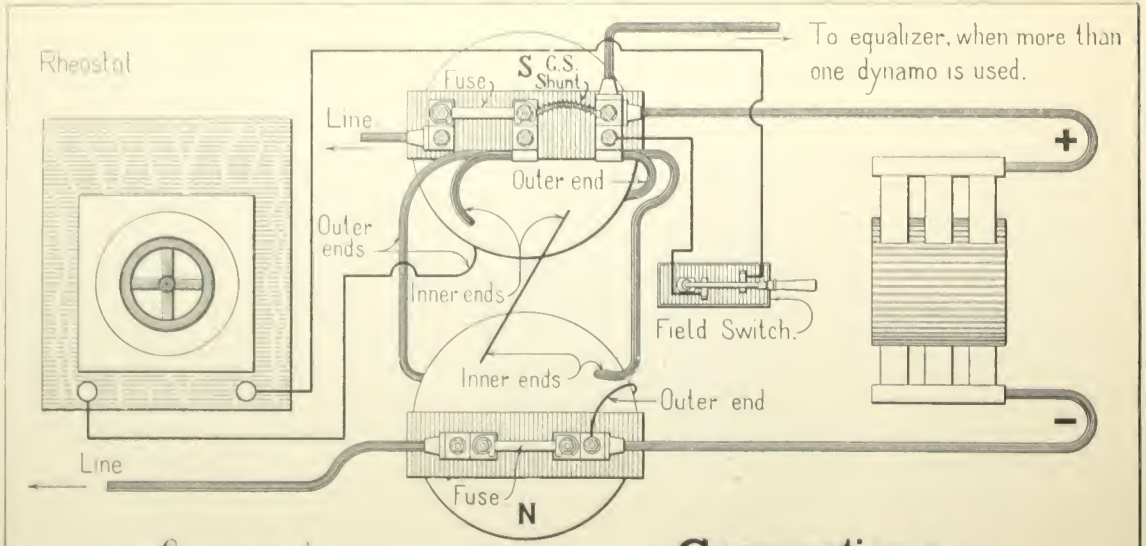
No. 3497. March 31, 1892.

CONNECTIONS OF D-3, D-5, D-7½, D-10, D-15 125 VOLT COMPOUND GENERATORS.



GENERAL ELECTRIC CO.

No. 3502. April 8, 1892.



No. 3455

Connections of D-20, D-25, D-30, D-40, D-50, D-62, D-90, 125-Volt Generators.

COMMUTATOR DATA TYPE D GENERATORS.

GENERATOR.		Number of Segments.	Diameter of Active Surface.		Useful Length of Commutator.
Class.	Volts.		Normal.	Minimum.*	
2	125	32	$2\frac{5}{16}$"	$1\frac{13}{16}$"	$1\frac{15}{16}$"
2	250	64	$3\frac{3}{8}$"	$2\frac{1}{8}$"	$1\frac{11}{16}$"
2	500	64	$3\frac{3}{8}$"	$2\frac{1}{8}$"	$1\frac{11}{16}$"
3	125		$3\frac{3}{8}$"	$2\frac{1}{8}$"	$1\frac{11}{16}$"
3	250	64	$3\frac{3}{8}$"	$2\frac{1}{8}$"	$1\frac{11}{16}$"
3	500	64	$3\frac{3}{8}$"	$2\frac{1}{8}$"	$1\frac{11}{16}$"
5	125	64	$3\frac{3}{8}$"	$2\frac{1}{8}$"	$3\frac{3}{16}$"
5	250	64	$3\frac{3}{8}$"	$2\frac{1}{8}$"	$3\frac{3}{16}$"
5	500	64	$3\frac{3}{8}$"	$2\frac{1}{8}$"	$3\frac{3}{16}$"
$7\frac{1}{2}$	125	48	3"	$1\frac{7}{8}$"	$3\frac{3}{16}$"
$7\frac{1}{2}$	250	64	$3\frac{3}{8}$"	$2\frac{1}{8}$"	$3\frac{3}{16}$"
$7\frac{1}{2}$	500	64	$3\frac{3}{8}$"	$2\frac{1}{8}$"	$3\frac{3}{16}$"
10	125	44	$4\frac{7}{8}$"	$3\frac{1}{8}$"	4"
10	250	56	$4\frac{7}{8}$"	3"	4"
10	500	64	$4\frac{7}{8}$"	$3\frac{1}{8}$"	4"
15	125	44	$4\frac{7}{8}$"	$3\frac{1}{8}$"	4"
15	250	88	$4\frac{7}{8}$"	$3\frac{1}{8}$"	4"
15	500	88	$4\frac{7}{8}$"	$3\frac{1}{8}$"	4"
20	125	80	6"	$4\frac{1}{8}$"	
20	250	80	6"	$4\frac{1}{8}$"	
20	500	80	6"	$4\frac{1}{8}$"	
25	125	72	$6\frac{1}{2}$"	$4\frac{7}{8}$"	$6\frac{5}{16}$"
25	250	72	$6\frac{1}{2}$"	$4\frac{7}{8}$"	$6\frac{5}{16}$"
25	500	72	$6\frac{1}{2}$"	$4\frac{7}{8}$"	$6\frac{5}{16}$"
30	125	70 long	7"	$5\frac{1}{8}$"	$6\frac{5}{16}$"
30	250	70 long	7"	$5\frac{1}{8}$"	$6\frac{5}{16}$"
30	500	70 short	7"	$5\frac{1}{8}$"	$5\frac{1}{16}$"
40	125	60	$7\frac{7}{8}$"	$5\frac{7}{8}$"	$6\frac{3}{8}$"
40	250	60	$7\frac{7}{8}$"	$5\frac{7}{8}$"	$6\frac{3}{8}$"
40	500	60	$7\frac{7}{8}$"	$5\frac{7}{8}$"	$6\frac{3}{8}$"
50	125	50 long	$8\frac{1}{4}$"	$6\frac{1}{8}$"	$7\frac{7}{16}$"
50	250	50 long	$8\frac{1}{4}$"	$6\frac{1}{8}$"	$7\frac{7}{16}$"
50	500	50 short	$8\frac{1}{4}$"	$6\frac{1}{8}$"	$5\frac{7}{16}$"
62	125	42	$8\frac{3}{8}$"	$6\frac{1}{4}$"	$7\frac{1}{2}$"
62	250	90 long	$8\frac{3}{8}$"	$6\frac{3}{8}$"	$7\frac{1}{2}$"
62	500	90 short	$8\frac{3}{8}$"	$6\frac{3}{8}$"	$5\frac{1}{16}$"
90	125	44	$10\frac{3}{8}$"	$7\frac{1}{2}$"	$11\frac{1}{8}$"
90	250	88	$12\frac{1}{2}$"	$10\frac{7}{8}$"	
90	500	88	$12\frac{1}{2}$"	$10\frac{7}{8}$"	

* Least possible safe thickness.

SPEEDS OF TYPE D GENERATORS.

KILOWATTS RATING AT 110, 220 AND 500 VOLTS.

	2	3	5	7.5	10	15	20	25	30	40	50	62	90
VOLTS	AMPERES OF 100–130 VOLT GENERATORS.												
	18	27	45	68	91	136	182	227	272	364	454	564	818
100	2000	1920	1820	1630	1490	1200	1100	1050	1000	950	840	750	650
105	2100	2020	1910	1720	1470	1250	1150	1100	1050	1000	880	790	680
110	2200	2110	2000	1800	1540	1300	1200	1150	1100	1050	920	820	720
115	2300	2210	2090	1880	1600	1350	1250	1200	1150	1100	950	840	750
120	2400	2300	2180	1960	1680	1400	1300	1250	1200	1125	980	870	780
125	2500	2400	2250	2050	1750	1450	1350	1300	1250	1170	1020	900	810
130	2600	2500	2360	2120	1820	1500	1400	1350	1300	1220	1060	930	850
	AMPERES OF 220–260 VOLT GENERATORS.												
	9	13.5	22.5	34	45	68	91	114	136	182	227	282	409
220	2200	2110	2000	1800	1540	1300	1200	1150	1100	1050	920	820	720
230	2300	2210	2090	1880	1600	1350	1250	1200	1150	1100	950	840	750
240	2400	2300	2180	1960	1680	1400	1300	1250	1200	1125	980	870	780
250	2500	2400	2250	2050	1750	1450	1350	1300	1250	1170	1020	900	810
260	2600	2500	2360	2120	1820	1500	1400	1350	1300	1220	1060	930	850
	AMPERES OF 500–550 VOLT GENERATORS.												
	4	6	10	15	20	30	40	50	60	80	100	125	180
500	2500	2400	2250	2050	1750	1450	1350	1300	1250	1170	1020	900	810
525	2625	2520	2360	2150	1840	1520	1410	1360	1310	1230	1070	940	850
550	2750	2640	2470	2250	1920	1600	1480	1420	1370	1280	1120	980	890

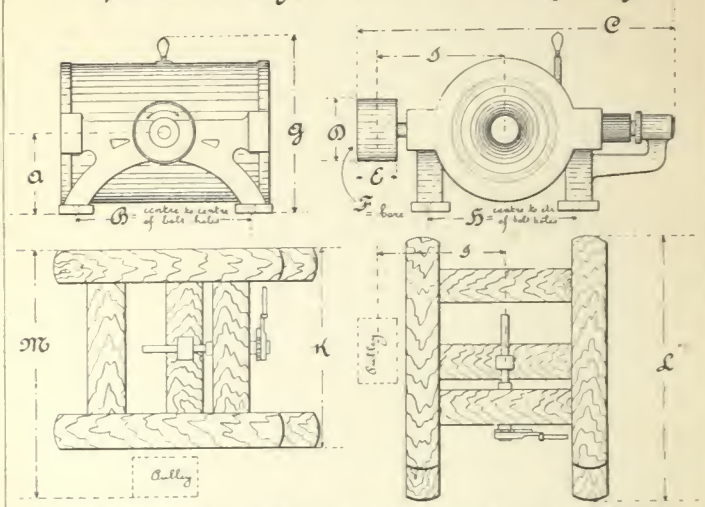
COPPER WOVEN WIRE BRUSHES FOR TYPE D MACHINES

100 TO 130 VOLTS

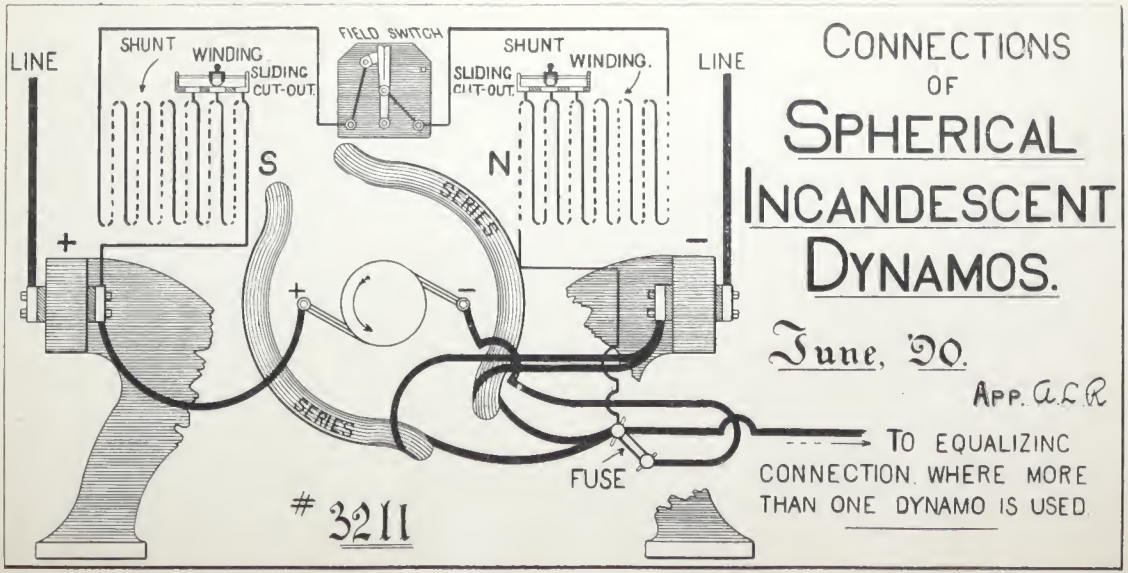
Grade		Length	Width	Thickness	No. per Holder	Cat. Number	
Old	Modern					Brushless	Light
0	0	4"	1/2"	1/4"	1	31018	31028
1	A	4"	5/8"	1/4"	1	31019	31029
2	B	4"	3/4"	1/4"	1	31020	31030
3	C	4"	7/8"	1/4"	1	31021	31031
4	D	4"	1"	1/4"	1	31022	31032
5	E	4"	1 1/8"	1/4"	1	31023	31033
6	F	4"	1 1/4"	1/4"	1	31024	31034
7	G	4"	1 3/8"	1/4"	1	31025	31035
8	H	4"	1 1/2"	1/4"	1	31026	
9	I	4"	1 5/8"	1/4"	1	31027	
10	J	4"	1 3/4"	1/4"	1	31028	
11	K	4"	1 7/8"	1/4"	1	31029	
12	L	4"	2"	1/4"	1	31030	
13	M	4"	2 1/8"	1/4"	1	31031	
14	N	4"	2 1/4"	1/4"	1	31032	
15	O	4"	2 3/8"	1/4"	1	31033	
16	P	4"	2 1/2"	1/4"	1	31034	
17	Q	4"	2 5/8"	1/4"	1	31035	
18	R	4"	2 3/4"	1/4"	1	31036	
19	S	4"	2 7/8"	1/4"	1	31037	
20	T	4"	3"	1/4"	1	31038	
21	U	4"	3 1/8"	1/4"	1	31039	
22	V	4"	3 1/4"	1/4"	1	31040	
23	W	4"	3 3/8"	1/4"	1	31041	
24	X	4"	3 1/2"	1/4"	1	31042	
25	Y	4"	3 5/8"	1/4"	1	31043	
26	Z	4"	3 3/4"	1/4"	1	31044	
27	AA	4"	3 7/8"	1/4"	1	31045	
28	AB	4"	4"	1/4"	1	31046	
29	AC	4"	4 1/8"	1/4"	1	31047	
30	AD	4"	4 1/4"	1/4"	1	31048	
31	AE	4"	4 3/8"	1/4"	1	31049	
32	AF	4"	4 1/2"	1/4"	1	31050	
33	AG	4"	4 5/8"	1/4"	1	31051	
34	AH	4"	4 3/4"	1/4"	1	31052	
35	AI	4"	4 7/8"	1/4"	1	31053	
36	AJ	4"	5"	1/4"	1	31054	
37	AK	4"	5 1/8"	1/4"	1	31055	
38	AL	4"	5 1/4"	1/4"	1	31056	
39	AM	4"	5 3/8"	1/4"	1	31057	
40	AN	4"	5 1/2"	1/4"	1	31058	
41	AO	4"	5 5/8"	1/4"	1	31059	
42	AP	4"	5 3/4"	1/4"	1	31060	
43	AQ	4"	5 7/8"	1/4"	1	31061	
44	AR	4"	6"	1/4"	1	31062	
45	AS	4"	6 1/8"	1/4"	1	31063	
46	AT	4"	6 1/4"	1/4"	1	31064	
47	AU	4"	6 3/8"	1/4"	1	31065	
48	AV	4"	6 1/2"	1/4"	1	31066	
49	AW	4"	6 5/8"	1/4"	1	31067	
50	AX	4"	6 3/4"	1/4"	1	31068	
51	AY	4"	6 7/8"	1/4"	1	31069	
52	AZ	4"	7"	1/4"	1	31070	
53	BA	4"	7 1/8"	1/4"	1	31071	
54	BB	4"	7 1/4"	1/4"	1	31072	
55	BC	4"	7 3/8"	1/4"	1	31073	
56	BD	4"	7 1/2"	1/4"	1	31074	
57	BE	4"	7 5/8"	1/4"	1	31075	
58	BF	4"	7 3/4"	1/4"	1	31076	
59	BG	4"	7 7/8"	1/4"	1	31077	
60	BH	4"	8"	1/4"	1	31078	

Incandescent Dynamos.

Spherical Type-For Isolated Lighting.



Class.	B S.	C S.	E S.	H S.
Net Weight.	700.	1200.	2250.	4400.
Speed.	1600.	1550	1250.	1150.
Lights-16 C.P.	60.	125	250.	450.
Watts	4000	8000	16000.	30000.
A	8 3/4	9 1/2	12 7/8	15 3/4
B	19 3/4	25 1/2	32 1/2	40 1/2
C.	31	37 1/2	48	62 1/4
D.	7	9	12	15
E.	5	7	10	12
F.	1 1/2	1 7/8	2 3/8	2 7/8
G.	—	27 1/2	33 3/4	38 1/2
H.	14 1/2	17 1/2	23 1/2	28 3/4
J.	12 1/2	14	19 5/8	25 3/4
K.	17 1/2	21 3/8	27 3/8	33 1/2
L.	30 3/4	38 1/2	45 1/2	54
M.	23 3/4	28 3/16	38 5/16	48 1/2



CONNECTIONS OF SPHERICAL INCANDESCENT DYNAMOS.

June, 90.

APP. A.L.R

COMMUTATOR DATA SPHERICAL INCANDESCENT.

CLASS.	VOLTS.	K.W.	NUMBER SEGMENTS.	DIA. ACTIVE SURFACE.		USEFUL LENGTH OF COMMUTATOR.
				Normal.	*Minimum.	
BI	75	3.84	48	3 "	1 7/8"	3 1/2 "
BI	110		48	3 "	1 7/8"	3 1/4 "
CI	75	7.68	48	3 "	1 5/8"	3 1/16"
CI	110	7.68	48	3 "	1 7/8"	3 1/16"
EI	75	14.40	64	4 1/2"	3 1/4"	4 1/16"
EI	110	14.40	88	4 1/2"	3 1/4"	4 1/16"
HI	75	28.80	44	7 3/4"	4 1/2"	6 5/8 "
HI	110	28.80	64	5 5/8"	4 1/2"	6 5/8 "

*Minimum is least safe diameter.